New Scientist

WEEKLY 15 October 2022

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Memory, the brain and who we are

How do our brains store past experiences to make us who we are? Why can memories feel so real? Are there such things as "true" and "false" memories? Psychiatrist Veronica O'Keane will offer a new way of thinking about our own personal experiences. Watch online at 6pm GMT/ 1pm EST on 10 November. Also available on demand.

newscientist.com/events

Tour

Science of the Arctic expedition cruise: Norway

Join our marine expedition exploring the northernmost region of Earth, the realm of the polar bear and the midnight sun. Gain extensive knowledge of marine and polar nature while deepening your connection to Svalbard, a remote and rugged archipelago. Led by marine biologist Helen Scales, the 13-day tour begins on 7 June 2023. Prices from £9345.

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Podcast

Weekly

Podcast editor Rowan Hooper talks to evolutionary biochemist Nick Lane about the chemistry of life, death and consciousness. The panelists also hear about a curious reduction in the number of male births in England and Wales in June 2020. And there is news of how mice are helping us understand why itching is contagious.

newscientist.com/nspod

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Polar science Go wildlife spotting in the Svalbard archipelago

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Baby puzzle Hear about a curious drop in male births in the UK

Video

New moon

A supercomputer simulation has suggested an alternative scenario for the formation of our moon. The consensus is that the moon formed slowly from the dust left when Earth collided with a Mars-sized object called Theia billions of years ago. But the new simulation suggests the moon might have formed immediately after the collision.

youtube.com/newscientist

Newsletter

Lost in Space-Time

Join physicist Sean Carroll as he explains how complex problems can be rendered simple by ignoring as many complications as possible. It is a strategy that works well in the realm of physics, but not in biology – leading to a famous joke about a spherical cow.

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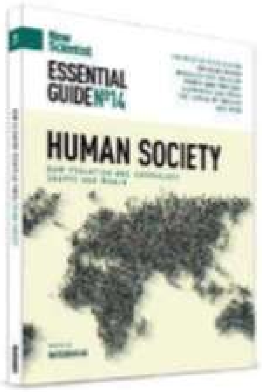
Newsletter

> "The reason that physics seems hard is, paradoxically, because it actually is easy"



Essential guide

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(Very) cool idea

Human hibernation may sound fanciful, but it could already be saving lives

IF YOU are in the northern hemisphere right now, you may well be channelling your inner bear as the colder months approach and life slows down. You leave your home less often, sleep more and perhaps develop some extra padding. Equally, you may be emerging from the cold spell in the southern hemisphere with renewed energy and the joys of spring.

What you might not realise is that this propensity to hunker down in winter could be a relic of our evolutionary past, as we discuss on page 46, and if scientists have their way, humans may once again be bestowed with the ability to hibernate – or at least mimic some of the effects of hibernation – to benefit our health and possibly allow long trips through space.

That might sound fanciful, but the truth is that a type of human hibernation is already being used in an attempt to save lives. Back in 2019, we broke the news that at least one patient with acute trauma such as a stab wound or gunshot had been placed in a state of "suspended animation", a holding pattern somewhere between life and death. Doctors at a Maryland hospital had achieved this by replacing the blood with a cold saline solution, cooling the body and slowing all internal processes, just like true hibernation. This astonishing technique afforded doctors hours rather than minutes for potentially life-saving surgery.

> "At least one patient had been placed in a holding pattern between life and death"

If the results of a trial on the technique – expected next year – are positive, there will no doubt be some questions over its use. How long could, or should, we place people in limbo for? Will it be acceptable to the public, and for what uses?

Tricky questions, but not impossible. In the 1960s, the idea of transplanting hearts provoked similar squeamishness and incredulity. But the thousands of heart transplants now carried out each year worldwide should show us that even the most outlandish ideas are worth investigating. Indeed, just like heart transplants, a positive outcome from the suspended animation trials may mark a fundamental turning point in the future of medicine – here on Earth, and beyond. ▮

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THE FUTURE OF LIFE SCIENCES IN A RAPIDLY CHANGING WORLD

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Our ability to develop, manufacture and distribute therapeutics has changed dramatically with covid, Brexit and the increasingly volatile geopolitical landscape. That has created numerous challenges for life sciences companies in the risks they face, in securing supply chains and in managing regulatory affairs. But periods of great change bring opportunities too as new products and approaches emerge and markets evolve.

Join our panel of experts to discuss the forces buffeting the biotech and pharmaceutical industries and the transformational changes that are becoming possible.

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Rainy days Sydney drenched by its wettest year on record **p9**

Down to earth Monkeys come out of the trees as climate warms up **p11**

Saving the Amazon Intensive farming could prevent further deforestation **p13**

Dangerous game Top rugby players face higher risk of dementia **p19**

Crustacean deaths Pollution may explain catastrophe on UK coast **p21**

YAMIL LAGE/AFP VIA GETTY IMAGES

Havana, Cuba, on 28 September after Hurricane Ian

Climate change

Extreme weather threat

Global energy systems are at risk from climate change, but many countries aren't taking this seriously, reports **Madeleine Cuff**

CLIMATE change could cause global energy crises equivalent to the impacts of Russia's war with Ukraine, according to the World Meteorological Organization.

In a year that has seen hurricanes, heatwaves and flooding bring electricity blackouts around the world, the WMO has issued an urgent call for countries to better prepare their power grids for the impacts of extreme weather.

"Changes in climate pose significant risks to the energy sector, directly affecting fuel supply, energy production, physical resilience of current and future energy infrastructure, and energy demand," it says in its latest *State of Climate Services* report released on 11 October.

The threat to the stability of energy systems is on the "same level" as Russian manipulation of gas markets, says Roberta Boscolo at the WMO.

Russia has been squeezing gas supplies to Europe in what experts believe is an effort to drive up prices, destabilise energy systems and force the West to weaken its opposition to Russia's invasion of Ukraine. Its tactics have sparked fears of blackouts this winter across Europe (see page 9).

But extreme weather has also driven energy instability this year. In the past month, millions of people across the US, Canada and Cuba have been hit by severe and widespread blackouts in the wake of hurricanes Ian and Fiona. In January, 7000 residents of Buenos Aires, Argentina, had their electricity supplies cut amid a record-breaking heatwave, and London narrowly avoided a blackout in July after power demand surged during a 40°C (104°F) heatwave.

> "Our climate is changing before our eyes. We need a transformation of the global energy system"

As climate change advances, increasingly extreme weather events will erode energy security around the world, the WMO warns in its report. Yet only 40 per cent of climate plans submitted to the UN under the Paris climate treaty prioritise national adaptation of the energy sector to climate impacts, it points out.

Analysis published last month by Climate Central, a non-profit research group, suggests that reported power outages across the US from extreme weather have jumped by 64 per cent in the past decade.

Robert Gross at Imperial College London says climate change poses a threat to energy systems "no less serious than war", particularly for low-lying countries vulnerable to flooding and sea level rise.

For the UK, the most pressing climate threat to electricity supply is likely to be storm damage to power infrastructure, he says. Nearly 1 million homes lost power during Storm Arwen in November 2021, with nearly 4000 without power for more than a week.

"The most common cause of power failure [in the UK] is when transmission or distribution networks are knocked out by severe weather," says Gross. "With severe weather events predicted to be more frequent and more damaging, this is the principal threat."

The WMO also called for a rapid rollout of low-carbon energy, warning that countries aren't moving fast enough to meet global net-zero goals. The supply of electricity from clean energy sources must double within the next eight years, while investments in renewable energy must triple by 2050, it said, citing analysis from the International Energy Agency.

"Time is not on our side, and our climate is changing before our eyes. We need a complete transformation of the global energy system," said Petteri Taalas, secretary-general of the WMO, in a statement. ▮

Health

Monkeypox threat could worsen

A more deadly variant of the virus is circulating in the Democratic Republic of the Congo, and there are fears it could go global, reports **Jason Arunn Murugesu**

THIS year's global outbreak of monkeypox has seen cases in more than 100 countries, with deaths outside the virus' endemic countries in West and Central Africa for the first time.

The World Health Organization's official death toll for the outbreak as of 7 October stands at 26, but this excludes large numbers of suspected deaths in countries where there is little laboratory testing. According to countries' own reported death tolls, the Democratic Republic of the Congo (DRC) is by far the worst-hit, with 120 suspected deaths between 1 January and 21 September.

"We know monkeypox is a problem in the DRC and it's at our own peril that we continue to ignore it"

The monkeypox virus that began spreading across the globe earlier this year is a variant called Clade II, previously known as the West African clade.

In the DRC, however, all the deaths in the ongoing outbreak have probably been caused by a more virulent variant of the virus called Clade I, previously the Congo Basin clade, a spokesperson for the World Health Organization (WHO) told *New Scientist*.

Historically, Clade I has had a case-fatality rate of 10.6 per cent, compared with 3.6 per cent for Clade II.

The only time Clade I has been reported outside of an endemic country was in South Sudan in 2005. However, the longer this variant is allowed to circulate in the DRC, the greater the risk it may spread to the rest of the world.

"It's certainly possible, given how travel around the world has become so commonplace," says Stuart Isaacs at the University of Pennsylvania.

DOTTED ZEBRA/ALAMY

Illustration of a monkeypox virus particle

The virus also replicates as it spreads, increasing the risk of new variants arising, just as we have seen during the coronavirus pandemic. "Monkeypox can continue to mutate and become more capable of transmission from person to person more efficiently," says Anne Rimoin at the University of California, Los Angeles.

Ultimately, it is unclear whether the DRC's disproportionately high number of monkeypox deaths is down to Clade I's case-fatality rate or the nation's less-advanced healthcare system compared with other African countries, says Andrea McCollum at the US Centers for Disease Control and Prevention.

120

Suspected deaths dues to monkeypox in the DRC in 2022

0

Number of monkeypox vaccines given in the DRC outside of trials

Like every country in Africa, the DRC hasn't received a single vaccine dose against monkeypox this year, outside of a clinical trial, says the WHO spokesperson.

As of 20 September, more than 45,000 people in the UK had received a dose of the vaccine Jynneos (also known as Imvanex and Imvamune), which is approved in Europe for preventing monkeypox and smallpox in people aged 18 and over.

In the US, more than 870,000 doses had been administered as of 4 October. Since 9 August, the vaccine has been approved for people under 18 in the US as part of an emergency use authorisation.

DRC officials are attempting to control the outbreak by isolating infected individuals and using contact tracing. According to Mario Stevenson at the University of Miami in Florida, this isn't enough to stop monkeypox.

While all the evidence points towards the DRC being in the centre of a particularly severe monkeypox outbreak, the true extent of the virus' burden there is unclear.

"We don't have the capacity to be able to go out and do all the surveillance that needs to be done," says Rimoin. "Especially in remote areas of the DRC where the vast majority of cases are, we don't have the ability to do lab analyses."

In May, officials at the WHO announced that the ongoing global outbreak is mainly spreading among men who have sex with men.

"It's not clear at this point how much of the spread in Africa [including the DRC] may be due to sex between men," says McCollum.

Global risk

The stigmatisation of homosexuality in many affected countries across Africa, such as the DRC, makes it difficult to understand the true pattern of monkeypox's transmission across the continent, she says.

When it comes to the global outbreak, it is unclear what caused Clade II to spread internationally earlier this year. According to Stevenson, the virus may have mutated and become more transmissible, or it might have simply infected a few people with frequent close contacts, enabling it to spread far and wide.

"We certainly know monkeypox is a problem in the DRC and it's at our own peril that we continue to ignore this problem," says Rimoin. "I think we have a short-term memory globally and what we need to be able to do is remember that an infection anywhere is potentially an infection everywhere." ▮

Analysis Energy

Can Britain avoid winter blackouts?

Households in England, Scotland and Wales could be required to ration their energy use at peak times to keep the lights on, reports **Madeleine Cuff**

MILLIONS of households in Britain may have to run their washing machines at night or their dishwashers during a mid-morning lull to avoid rolling blackouts this winter.

On 6 October, National Grid ESO, which operates the electricity grid in England, Scotland and Wales, issued a stark winter outlook, warning that electricity supplies to households could be cut for 3 hours at a time this winter if the European energy crisis deepens.

"I'm not aware of there ever having been planned rolling blackouts since the 1970s," says Simon Cran-McGreehin at the Energy and Climate Intelligence Unit, a UK non-profit organisation. "This is, in terms of our modern energy system, unprecedented."

National Grid ESO said it is "cautiously confident" that it can keep the lights on across the three countries this winter, assuming that European interconnectors are available to send power to Britain as usual, and that gas supplies continue uninterrupted. But things could spiral downwards swiftly if conditions on the continent change, the operator warned.

IMGORTHAND/GETTY IMAGES

Families in Britain may have to prepare for rolling blackouts

Interconnector cables from mainland Europe currently supply about 8 per cent of Britain's electricity. But if Europe starts to run out of gas, power generation on the continent could slump, leaving little spare electricity to send to Britain.

If supplies from Belgium, France and the Netherlands were stopped this winter, Britain's generation capacity would drop by almost 4 gigawatts, National Grid expects, wiping out the safety margin for electricity supply over the winter.

If this happens, National Grid has a plan to fire up Britain's ageing fleet of coal-fired power stations, providing an extra 2 GW of capacity to help fill the supply gap. Operators will also be keeping their fingers crossed for blustery days to generate plenty of homegrown wind power. But that will only solve part of the problem. More power capacity would still be needed to fill the supply gap.

That is where British households and businesses will need to step in. Since February, National Grid has been trialling a new "demand flexibility service" that asks households and businesses to tweak their energy use to ease pressure on the network at key times.

A trial with Octopus Energy earlier this year involving tens of thousands of customers saw households cut their consumption by an average of 18 per cent during specified periods, saving an average of 23p each time. Two-thirds of households cut their usage by at least 30 per cent in at least one event.

Once rolled out across Britain, National Grid estimates this response could cut demand by up to 2 GW. That would be a "significant chunk" shaved off the total demand on the grid, says Cran-McGreehin.

But such a large-scale programme of demand reduction is relatively untested, with trials only starting in earnest this year. For it to have a meaningful impact on Britain's power demand, millions of homes and businesses would need to be involved and primed to take action at the right time. That will require an unprecedented communications effort on the part of National Grid, energy suppliers, the UK government and devolved governments.

8%

of Britain's electricity is supplied by mainland Europe

Even if people voluntarily cut demand at key times, controlled blackouts might be inevitable if a shortfall of gas means there isn't enough fuel to keep gas-fired power turbines going, National Grid warned. ▮

Extreme weather

2022 is already Sydney's wettest year on record

ENOUGH rain has drenched Sydney since January to set a new annual record, with more than 2.2 metres having fallen by early October.

Previously, the city's wettest year was 1950, when the total annual rainfall was 2.194 metres. This year's precipitation topped that figure at around 1pm on 6 October. In an average year, Sydney only gets about 1.2 metres of rain.

With almost a quarter of the year left to go and wet conditions predicted to continue, 2022 is likely to be the wettest year on record in the city by a long margin, says Milton Speer at the University of Technology Sydney.

There are several reasons why it has been so wet, he says. One is that, for the third year in a row, the east of Australia is seeing a La Niña weather cycle, which attracts moist onshore winds from the Pacific.

Another is that there has been a series of low-pressure weather features that have "focused the rain for extended periods on Sydney and other parts of the coast", says Speer. In addition, a weather cycle called the Indian Ocean Dipole that affects countries around the Indian Ocean, including Australia, has recently moved into its negative phase, which is increasing rainfall in the Sydney area even further.

MUHAMMAD FAROOQ/AFP VIA GETTY IMAGES

Flooding in the Sydney suburb of Pitt Town in July this year

Finally, climate change may be exacerbating the wet conditions by raising sea surface temperatures so that there is more evaporation and more moisture in the air to fall out again as rain, says Speer.

The deluge has already caused repeated flooding in Sydney, particularly in areas near the Hawkesbury and Nepean rivers, where residents have been evacuated four times this year. Homes, shops and infrastructure have been damaged and four people have drowned. As *New Scientist* went to press, three more days of heavy rain were forecast to hit the city from 12 October. ▮

Alice Klein

New Scientist Live

Nine nuggets from our big show

The world's greatest festival of science entertained and educated us – it also revealed some rather surprising facts, finds **Matthew Sparkes**

OUR flagship event, New Scientist Live, finished on Sunday after three days of mind-expanding talks and exhilarating experiences. Thousands of people attended each day, meeting robots, trying cutting-edge virtual reality set-ups and learning everything from whether science can save humanity to the "design" flaws in the human body. Most importantly, we had an amazing time (see page 28 for more). Here are nine incredible things we learned there.

1. Just like humans, gorillas make noises when they eat – and better food elicits different sounds. We heard psychologist Gillian Forrester explain that we may be able to shed light on the mystery of how human speech evolved by studying these great apes.

2. The first person to notice climate change lived in the 11th century. Atmospheric physicist Simon Clark talked about what weather is, how the atmosphere is changing – and how the first person to notice climate change was a polymath called Shen Kuo in the 11th century. He realised that the climate had altered after discovering fossilised bamboo. In a 1088 work called *Dream Pool Essays*, Shen wrote about how a landslide exposed a cavity inside which bamboo plants "had turned to stone". These fossils led Shen to suggest that the climate in the region must have been different in the distant past – making his work arguably the first written account of how the climate in specific places could change over time.

"It isn't true that only cancer cells have 'cancer-causing mutations'"

TIM BODDY

Gillian Forrester talked about how the sounds gorillas make when they eat can shed light on the evolution of speech

3. Placing greater priority on science will lead to greater military security, more resilience to future threats from pandemics and climate change, and will also boost the UK's economy, according to Patrick Vallance, the government's chief scientific adviser. "The current government seems to have quite a focus on growth. And if you want growth, then you have to have science, engineering and technology," he said. Vallance called for all UK government departments to consult more experts on science, technology and engineering, and for more graduates in these fields to be employed in the civil service.

Patrick Vallance speaking on the Future Stage

4. Ultra-processed foods are the main driver of obesity today, revealed twin doctors Chris and Xand van Tulleken from children's television series *Operation Ouch!*. They said ultra-processed foods now make up 60 per cent of the average diet in the UK – and virtually 100 per cent for many young babies. They claimed that these types of food are the main driver of obesity today, because we tend to eat more calories when processed food is on the menu. "It's our national diet," said Chris van Tulleken. "It's what we build our bodies from and the bodies of our children from."

5. It isn't true that only cancer cells have "cancer-causing mutations". Science writer Kat Arney delved into some of the surprising science behind cancer. We find cells with cancer-like mutations even in people without cancer. Arney said that if these mutations were seen in tumour cells taken in a biopsy, doctors would assume these were what had caused the cancer, so clearly science has more to learn.

6. Nothing draws the crowds as consistently as a Boston Dynamics Spot robot, which spent the three days of the show trotting around its enclosure and interacting with big crowds. The event was no doubt an easier assignment than Spot's other job: assisting the UK Atomic Energy Authority with safe inspection and decommissioning of nuclear power plants.

7. A little greenhouse gas is actually needed, said geoscientist Chris Jackson. Without any at all, the world's temperature would be an average -20°C (-4°F). But there can obviously be too much as well: our climate is entering an anthropogenic era in which human-created emissions are pushing temperatures ever higher.

8. The hottest point in the solar system isn't the sun, but in a building near Oxford, revealed Joe Milnes from the UK Atomic Energy Authority. The plasma inside the JET fusion reactor can reach 150 million °C, many times hotter than the surface of the sun. Working out how to contain that heat and use it to generate electricity for us is a massive engineering challenge.

9. Three of Astronomer Royal Martin Rees's colleagues have opted to be frozen after death, in the hope of future revival. "I told them I'd rather end my days in an English churchyard than in an American freezer," he said. ∎

New Scientist Live will return on 7 and 8 October 2023 – advanced tickets are already available. We look forward to seeing you there

Wildlife

Climate change forces monkeys out of the trees

Madeleine Cuff

TREE-DWELLING species of monkeys and lemurs are spending increasing amounts of time on the ground as they seek refuge from rising temperatures.

Scientists say the shift from arboreal lifestyles is a "concerning" sign that the primates are struggling to survive in forests damaged by human activity and climate change.

The warning follows a study based on more than 150,000 hours of observations of 47 tree-dwelling primate species living across almost 70 sites in Madagascar and the Americas. It found some primates, including howler monkeys (*Alouatta*) and bamboo lemurs (*Hapalemur*), are spending more time on the ground in areas where their forest is degraded and fragmented (*PNAS*, doi.org/jgds).

The animals are being forced to descend to seek shade and water to recover from rising temperatures higher in the forest canopy, says Giuseppe Donati at Oxford Brookes University in the UK, a member of the study team.

"In most tropical countries where these species live, humans log the forest," he says. "This creates gaps and it opens the canopy of the forest. That causes an increase in temperature. The deforestation is working together with climate change [to force primates to the ground]."

Species that live in large groups and those that eat foods other than fruit are among those most likely to spend more time on the forest floor, the study concluded.

It suggests these more flexible species may be able to partially adapt their lifestyles in response to climate change and habitat loss, at least in the short term. But the animals can't adapt quickly enough to keep pace with the changes in their habitat, says Timothy Eppley at the San Diego Zoo Wildlife Alliance in California.

Analysis **Armed robots**

The stand against robots with guns

Robot-makers have pledged to push back on attempts to add weapons to their creations. Will it make a difference, asks **Matthew Sparkes**

A GROUP of robotics companies has pledged not to add weapons to their devices and to push back against attempts by other people to do so. But how big an effect will it have if other firms will be developing robots with military applications?

An open letter signed by Agility Robotics, ANYbotics, Boston Dynamics, Clearpath Robotics, Open Robotics and Unitree says "untrustworthy people" could use the companies' devices to "invade civil rights or to threaten, harm, or intimidate others". The companies pledge not to weaponise their robots, or help others to do so, and to "explore the development of technological features that could mitigate or reduce these risks".

They also call on legislators to look at ways to prohibit robot misuse. The letter doesn't supply ideas on how prohibitions might work, but there are precedents in drone-makers being forced to get their drones to adhere to no-fly zones around government buildings and other sensitive areas. Within these areas, the devices won't take off, or will stop and hover if they enter one.

The Atlas robot made by Boston Dynamics can dance fluidly

JOSH REYNOLDS/AP/SHUTTERSTOCK

Companies creating robots that can refuse to carry guns is a more ambiguous and complex task than simply blocking the ability to work in certain areas, however.

"It's hard to know what they might do to stop it," says Matthew Studley at the University of the West of England, UK. "Until a robot is sufficiently self-aware to know what's happening to it, you can't stop this from happening."

350

The number of Kobra 725 robots bought by the US military

Robots from Boston Dynamics are already being put to work, doing things like taking people's temperatures or measuring radiation levels. But there have been instances of robots carrying out less peaceful activities. One involved what looked like a Unitree four-legged robot that had been adapted by unknown parties to fire at targets with a gun strapped to its back. Such unsanctioned applications seem to be what has sparked the open letter.

Although some robotics companies are distancing themselves from the possibility of arming their devices, others, like Ghost Robotics, have been developing set-ups that can be armed and marketing them at trade conferences. The firm is working with a few armed forces, and its products are being put to work guarding a US military base.

Ghost Robotics didn't respond to an interview request, but chief executive officer Jiren Parikh said last year that real-world military use of its robots is some way off. "It's primarily going to be a special force thing in the US, and we're talking years by the time they get official approval," he said.

Teledyne FLIR makes products for military use, including the Kobra 725, which can lift heavy loads, break down doors and be fitted with weapons. The US Army has purchased 350 of the robots and says some are already in use.

Boston Dynamics didn't respond to a request for comment. Robotics research and military funding often go hand in hand. Despite its current objection to weaponisation, many of Boston Dynamics's early projects were funded by the US Defense Advanced Research Projects Agency, which develops emerging technology for use by the military.

With companies including Amazon and Tesla now working on robotics, as well as a clutch of mature start-ups, military institutions and the defence industry, we are likely to see rapid advances in what robots of all kinds are capable of. But the technology is still some way off being truly useful in a conflict.

"The capabilities of walking robots, especially in more dynamic, higher intensity, war-fighting situations, are sometimes overstated," says Anthony King at the University of Warwick, UK. "If something goes slightly wrong, or slightly different to plan, mechanically they really struggle."

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Space

Adverts in space are now economically viable but potentially dangerous

Alex Wilkins

COMPANIES could use constellations of satellites that reflect sunlight to Earth to create advertisements in the sky at a commercially viable cost of $65 million per mission, according to a feasibility study. But the idea is controversial among researchers, who warn of a pile-up of dangerous space debris and light pollution for ground and space-based telescopes.

Previous proposals for space advertising didn't make commercial sense – the cost of launching enough satellites, which tend to remain in the correct orbit for only a short amount of time, has been prohibitive.

But as launch costs have decreased with the advent of private space companies, Shamil Biktimirov at the Skolkovo Institute of Science and Technology in Moscow, Russia, and his colleagues think it could now be viable if the mechanics of how the satellites are used as advertising are reassessed.

To do this, they borrowed techniques that describe the dynamics of mega-constellations, such as that of Starlink's communications satellite fleet, and used this to calculate how much revenue companies could get for keeping their satellites in the sky for certain lengths of time.

The researchers propose that a fleet of about 50 satellites with curved reflectors could orbit around the line where day turns to night and reflect the sun's light to a patch of ground below. They would be arranged to form an image made of bright pixels showing a logo or a basic image. Viewers on the ground would see the constellation move across the sky in about 10 minutes around dawn or dusk, growing from half-moon size to two to three times bigger than the moon at its peak.

To maximise revenue, the satellites would change formation around 25 times to target different locations in a three-month period of operation before the satellites run out of fuel and slowly descend towards Earth and – Biktimirov hopes – burn up (*Aerospace*, doi.org/gqxwjz).

Large satellite fleets are already used to offer internet services

JACQUES DAYAN/SHUTTERSTOCK

But this long descent could be a problem. "The spaceflight risk from debris related to these objects is considerable," says John Barentine of Dark Sky Consulting, a company based in Tucson, Arizona. "Left derelict in orbits with long lifetimes, every single object becomes a potential 'bullet' that threatens every other object in similar orbits. Any one might set off a catastrophic cascade of debris generation." The reflected light from space advertising would also interfere with astronomy, he adds.

Biktimirov and his team say the descent of the satellites and any potential collisions could be monitored, but some are sceptical about how accurately this could be done. "The debris is especially concerning, given that tracking objects and satellites across a range of sizes and orbital parameters is inherently challenging," says Aparna Venkatesan at the University of San Francisco, California. ■

Environment

Intensive farming could preserve remaining Amazon

ENCOURAGING more intensive farming in areas of the Brazilian Amazon rainforest that have already been felled could help preserve the rest of the rainforest, by boosting crop yields without serious environmental impacts, researchers have found.

For decades, Brazilian farmers have been logging large tracts of the Amazon, a practice that drives the country's economic growth, but has catastrophic environmental consequences. Deciding the future use of the rainforest is a key part of Brazil's current general election, which will see a second round of voting on 30 October.

Patricio Grassini at the University of Nebraska-Lincoln and his team say that instead of logging more areas of virgin forest to create new farmland, farmers should stock more cattle on ranches and use fertilisers, irrigation systems and better soil management to boost production of soybeans – its largest national export – in existing fields.

The team simulated a range of intensification scenarios and found that if farmers did this, it could allow Brazil to increase its soybean production by 36 per cent by 2035 without any further deforestation. The environmental impact would be "negligible" compared with that of further deforestation, says Grassini (*Nature Sustainability*, doi.org/jgdt).

If Brazil fails to take action to stem the deforestation rate, 5.7 million hectares of virgin forest and savannah could be cleared for soybean production over the next 15 years, the team found.

> "It is difficult to protect forests and biodiversity while being sensitive to economic aspirations"

"Without an emphasis on intensifying crop production within the existing agricultural area… it would be difficult to protect the last bastions of forests and biodiversity on the planet while being sensitive to the economic aspirations of countries to develop," says Grassini.

However, he says that "strong institutions and policies that prevent deforestation" would be needed to stop illegal logging in areas that back onto virgin forest. ■

Madeleine Cuff

Mathematics

AI trick speeds up multiplication

A new way to perform "matrix multiplication", discovered by a DeepMind artificial intelligence, could boost a range of computing tasks, reports **Matthew Sparkes**

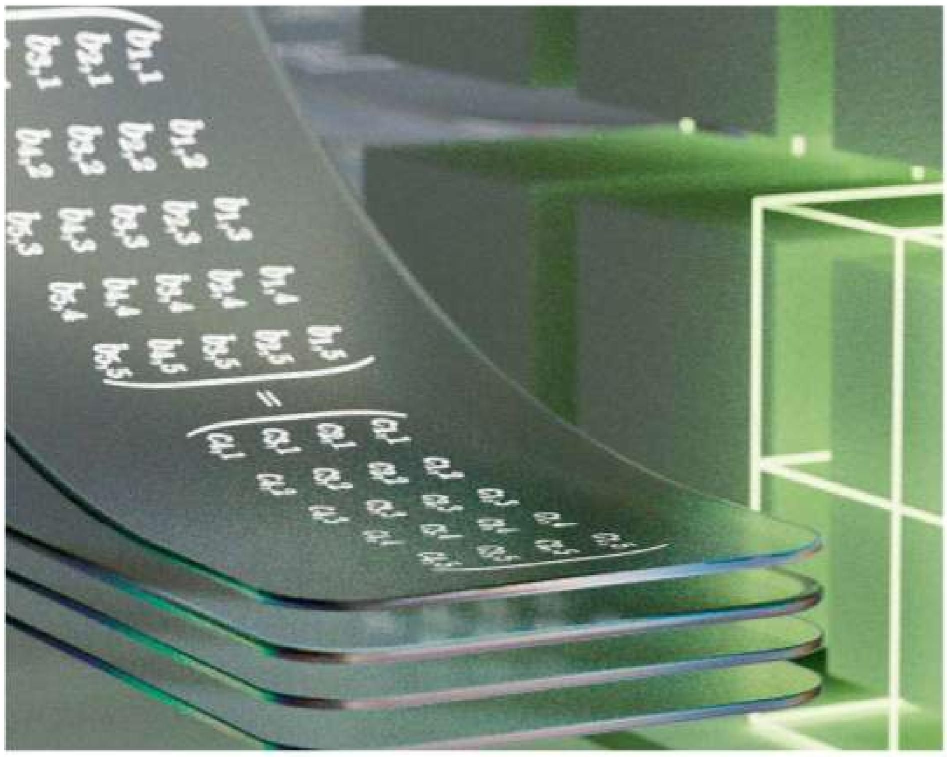
AN ARTIFICIAL intelligence created by the firm DeepMind has discovered a new way to multiply numbers, the first such advance in over 50 years. The find could boost some computation speeds by up to 20 per cent, as a range of software relies on carrying out the task at great scale.

Matrix multiplication – where two grids of numbers are multiplied together – is a fundamental computing task used in virtually all software to some extent, but particularly so in graphics, AI and scientific simulations. Even a small improvement in the efficiency of these algorithms could bring large performance gains or significant energy savings.

For centuries, it was believed that the most efficient way of multiplying matrices would be proportional to the number of elements being multiplied, meaning that the task becomes proportionally harder for larger and larger matrices.

But in 1969, the mathematician Volker Strassen proved that multiplying a matrix of two rows of two numbers with another of the same size doesn't necessarily involve eight multiplications and that, with a clever trick, it can be reduced to seven. This approach, called the Strassen algorithm, requires some extra addition, but this is acceptable because additions in a computer take far less time than multiplications.

The algorithm has stood as the most efficient approach for most matrix sizes for more than 50 years, although some slight improvements that aren't easily adapted to computer code have been discovered.



DEEPMIND

Matrix multiplication is a fundamental task in computing

However, DeepMind's AI has now found a faster technique that works perfectly on current hardware. The company's new AI, AlphaTensor, started with no knowledge of any solutions and was asked to create a working algorithm that completed the task in the fewest steps.

It found an algorithm for multiplying two matrices of four rows of four numbers using just 47 multiplications, which outperforms Strassen's 49 multiplications. It also developed improved techniques, 70 in total, for multiplying matrices of other sizes (*Nature*, doi.org/gqxw7g).

AlphaTensor discovered thousands of functional algorithms for each size of matrix, including 14,000 for 4×4 matrices alone. However, only a small minority were better than the state of the art. The research builds on AlphaZero, DeepMind's game-playing AI, and has been two years in the making.

Alhussein Fawzi at DeepMind says the results are mathematically sound, but are far from intuitive for humans. "We don't really know why the system came up with this, essentially," he says. "Why is it the best way of multiplying matrices? It's unclear. Somehow, the neural networks get an intuition of what looks good and what looks bad. I honestly can't tell you exactly how that works. I think there is some theoretical work to be done there on how exactly deep learning manages to do these kinds of things."

DeepMind found that the algorithms could increase computation speed by between 10 and 20 per cent on certain hardware such as an Nvidia V100 graphics processing unit (GPU) and a Google tensor processing unit v2, but there is no guarantee that those gains would also be seen on common devices like a smartphone or laptop.

> **"We don't really know why the system came up with this. I honestly can't tell you exactly how it works"**

James Knight at the University of Sussex, UK, says that a range of software run on supercomputers and powerful hardware, like AI research and weather simulation, is effectively large-scale matrix multiplication.

"If this type of approach was actually implemented there, then it could be a sort of universal speed-up," he says. "If Nvidia implemented this in their CUDA library [a tool that allows GPUs to work together], it would knock some percentage off most deep-learning workloads, I'd say."

Efficiency improved

Oded Lachish at Birkbeck, University of London, says the new algorithms could boost the efficiency of a wide range of software because matrix multiplication is such a common problem – and more algorithms are likely to follow.

"I believe we'll be seeing AI-generated results for other problems of a similar nature, albeit rarely something as central as matrix multiplication. There's significant motivation for such technology, since fewer operations in an algorithm doesn't just mean faster results, it also means less energy spent," he says. If a task can be completed slightly more efficiently, then it can be run on less powerful, less power-intensive hardware or on the same hardware in less time, using less energy.

But DeepMind's advances don't necessarily mean human coders are out of a job. "Should programmers be worried? Maybe in the far future. Automatic optimisation has been done for decades in the microchip design industry and this is just another important tool in the coder's arsenal," says Lachish. ■

Solar system

Taking lava's temperature on Jupiter's moon Io

Will Gater

LAVA erupting on Jupiter's volcanic moon Io is more than 1000°C, according to a new estimate made using radio telescopes.

Erin Redwing at the University of California, Berkeley, and her colleagues analysed observations of Io's atmosphere made using the Atacama Large Millimetre/Submillimetre Array (ALMA) – a collection of radio telescopes operated by the European Southern Observatory within Chile's Atacama desert.

The study focused on sodium chloride and potassium chloride gases that are thought to be belching from lava lakes and magma chambers on Io. By comparing the amounts of the two gases, the team was able to estimate how hot the sources of the gases are.

"The ratio of [sodium chloride to potassium chloride] gas abundance in Io's atmosphere will change depending on the thermochemical conditions of the magma chambers from which they are outgassed, so by observing their abundance ratios we can indirectly infer the temperature," says Redwing.

The researchers found that the magma on Io is probably about 1300 kelvin, or just over 1000°C – similar to the temperature of lava from volcanoes on Earth. However, the resolution of the ALMA observations wasn't sufficient to allow the team to pin down the precise locations of the features where those temperatures arise (arxiv.org/abs/2209.12974).

"This study confirms that the lavas erupting on Io are likely mostly basaltic in composition, based on their temperature," says Jani Radebaugh at Brigham Young University in Utah. This would make them similar to the molten rock that has emerged on the floor of Earth's oceans as well as the moon, Venus and Mars, she says. ▮

Health

Smoking and body mass linked to 226 conditions

David Cox

OUR smoking status and body mass index (BMI) are together linked to 226 medical conditions, from heart failure to nail disorders.

Anthony Webster at the University of Oxford used data on 500,000 participants of the UK Biobank study to estimate the extent to which smoking or our BMI influences our risk of various conditions. BMI uses your weight and height to calculate if your weight is healthy.

In 11 of the 226 conditions, smoking or our BMI may be responsible for more than half of the condition's onset, with genetics or other lifestyle habits contributing to the rest.

For example, atherosclerosis, when the arteries become clogged, is 73 per cent down to smoking or BMI, with other factors making up the remaining 27 per cent, the study suggests (medRxiv, doi.org/jf3s).

"The proportions of diseases in the study that are attributed to smoking and/or BMI is quite staggering," says Webster. "Most of the strong associations with specific diseases have been observed by prior publications, but many of these associations have only become recognised recently."

For example, our BMI influences our risk of nerve damage and degeneration of the spine, while smoking may cause fungal infections or affect the ulnar nerve, which transmits signals to muscles in the forearm and hand, says Webster.

Filippos Filippidis at Imperial College London hopes the findings may remind people of the health risks associated with smoking and certain BMIs, particularly being overweight.

73%

The amount smoking or our BMI contributes to atherosclerosis

"I think this helps highlight to policy-makers how urgently we need to work to address these problems," he says.

Others have called for a note of caution regarding some of the more obscure associations with conditions. For example, while the study suggests that smoking and our BMI might influence our susceptibility to flu and tension headaches, several factors may be involved.

Although Webster accounted for the participants' educational status and socioeconomic background, factors such as stress may also be at play, says Gemma Taylor at the University of Bath, UK.

"We have to look at whether there's a plausible biological pathway between smoking, BMI and each of these diseases," says Taylor.

Perhaps surprisingly, the study also suggests that smoking may protect against some conditions, such as Parkinson's disease.

While various ideas have been put forward as to why smokers may be less likely to develop this condition, including speculation about nicotine's neuroprotective effects, scientists are yet to find a satisfactory explanation.

"I'm always quite suspicious of protective effects, especially when it comes to smoking because you often get a survivor bias," says Taylor. "You often see in epidemiology that smoking appears to protect against dementia, while all that's happened is that everyone who didn't get dementia died earlier from lung cancer."

Overall, the research highlights how the burden on healthcare services could be reduced by encouraging people to quit smoking and maintain a healthy weight, says Taylor.

"It makes us realise that actually we've got two huge causes of disease morbidity which are both very preventable," she says. ▮

SCARC/SHUTTERSTOCK

Smoking and our body mass index may play a part in many conditions

Parched Earth
A series on the North American megadrought
newscientist.com/megadrought

Environment

Drought could be the new normal

South-western North America has been in drought for more than two decades, and with the influence of climate change, this could become permanent, finds **James Dinneen**

EXCEPTIONALLY bad droughts – or megadroughts – are part of natural climate variability. Yet in places most vulnerable to these extreme events, such as south-western North America, human-caused global warming could shift background temperatures and precipitation such that drought becomes the new normal.

> **"We are not going to be able to go back to the climate of the past. We are changing the whole system"**

TOM GRUNDY/ALAMY

South Lake reservoir in California has low water levels due to drought

A drought is, by definition, something that comes to an end. "A drought is a temporary period of below-normal water availability," says Benjamin Cook at Columbia University in New York. Even megadroughts that lasted for centuries eventually ended with the return of wetter years. But what happens when normal itself changes?

Cook and his colleagues looked at research on the global record of drought over the past 2000 years. They reviewed studies that had examined distinctive patterns left in tree rings, lake sediments, stalagmites and other natural records to identify the timing and severity of droughts prior to modern records and found that exceptionally long-lasting, severe or widespread droughts have played out on every continent except for Antarctica in the past two millennia.

With the context provided by this long-term record, the researchers then considered how both natural climate processes and human-caused climate change might influence these extreme events in the future, synthesising results from different climate modelling studies.

They found that regions already vulnerable to megadrought under natural climate variability are likely to see this risk increase with warming (*Nature Reviews Earth & Environment*, doi.org/gqxr7t). This is mostly due to higher temperatures, rather than expected changes in overall precipitation.

"As you warm the air, the air's demand for water increases," says Park Williams at the University of California, Los Angeles, a co-author of the research. Warmer air can hold more moisture, meaning less water is left in waterways or the soil.

In previous work, Williams and his colleagues found that human-caused climate change accounted for about 46 per cent of the severity of the current megadrought in south-western North America. They concluded that warming contributed to the drought mainly by drying out soil and reducing the amount of precipitation falling as snow, leaving less snowpack to provide a reservoir of water for the drier, warmer months.

According to their work, the rest of the drought was mainly driven by the recurring pattern of sea surface temperature in the Pacific Ocean known as La Niña, which can interact with the atmosphere to affect the climate in distant regions. Without the added effect of human-caused warming, however, the drought probably wouldn't have become a megadrought, says Park.

22
years that south-western North America has been in drought

46%
Share of US drought severity attributable to climate change

1200
years since North America had a drought this severe

Depending on greenhouse gas emissions, future warming might push things even further in some places, changing average temperature and precipitation to create a sort of perpetual drought – what the researchers call a "new climate normal".

"If you move into a brand-new baseline with climate change, where even the wet years are just equal to the normal years in the past, then by that definition you're kind of permanently in drought," says Cook. "This is challenging the way we think about drought."

Under a moderate emissions scenario, the researchers found the regions at highest risk of shifting to drier conditions by the end of this century are south-western North America, Australia, central and South-East Asia, the Mediterranean and western South America – which is now in a megadrought. West and East Africa, South Asia and northern China would see a small increased risk of megadrought as well.

Under a very high greenhouse gas emissions scenario, modelling by Samantha Stevenson at the University of California, Santa Barbara, and her colleagues found that southern Africa, south-western North America, western Europe and Australia would have megadrought-like conditions for much of the 21st century.

"We're not going to be able to go back to the climate of the past 2000 years," says Cook. "We are fundamentally changing the whole system and shifting it." ▮

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Health

Dementia risk for rugby players

Health records reveal a higher incidence of neurological conditions in men who played rugby union at international level, reports **Jason Arunn Murugesu**

MEN who played rugby union at international level are more than twice as likely to develop dementia as the general population. The finding increases the pressure on the sport's governing bodies to limit players' exposure to head injuries.

Previous studies have found that heading the ball in soccer is linked with increased dementia risk, and that American football players are more likely than other people to die from neurodegenerative conditions.

William Stewart at the University of Glasgow in the UK and his colleagues analysed the medical histories and death certificates of 412 male Scottish rugby union players who had all been born between the early 1900s and 1990 and had played the game to an international level. The researchers wanted to determine what effect playing rugby at this level had on neurodegenerative risk.

The rugby players were each matched to three members of the general population by age, sex and socioeconomic status. By matching rugby players to non-rugby players using these characteristics, the researchers could be more certain that any differences they found in neurodegenerative risk were due to playing rugby.

Scotland men's team facing England in the Five Nations in 1981

MIRRORPIX/ALAMY

Through NHS Research Scotland, the team was able to access death certificate and medical prescribing data on the rugby players and other individuals with identifying information removed.

In the UK, approximately 1 in 14 people over the age of 65 and 1 in six over the age of 80 develop dementia, says Stewart. The analysis found that the rugby union players were 2.2 times more likely to develop dementia than the rest of the population. It also found that the rugby players were three times more likely to develop Parkinson's disease than people in the general population and 15.2 times more likely to develop motor neurone disease.

Over a median of 32 years, 11.4 per cent of the rugby players were diagnosed with a neurodegenerative condition, compared with 5.4 per cent of the comparison group. A neurodegenerative condition was the primary cause of death in 2.7 per cent of the rugby players, compared with 1.5 per cent in the general population group (*Journal of Neurology, Neurosurgery and Psychiatry*, doi.org/jf3d).

> **"We might have to say that the number of games being played at the moment is unacceptably high"**

The rise in neurodegenerative conditions is probably due to the athletes sustaining a greater number of head injuries. "When we have the opportunity to examine the brains of people who have participated in contact sports and develop dementia, we find this unique pathology in the brains," says Stewart. "It's something we only see in people who have been exposed to brain injury and we don't see anywhere else."

Many of the rugby players in this analysis played the game at a time when it was amateur. Professional rugby players today probably devote much more time to playing and training, and may face even greater risks, says Stewart.

"From the advent of the professional game, people have grown fitter, faster, heavier and stronger," he says. "The number of matches has gone up, concussion levels have gone up and so you know it's much more physically demanding than it used to be. You would have to imagine that the risk is higher than it's ever been."

Protecting players

Stewart says he hopes that rugby's leaders take the research seriously. "We might have to take the difficult decision and say that the number of games of rugby being played at the moment is unacceptably high. And perhaps we need to try and reduce contact training as much as possible," he says.

"There is an immediate need to protect active players from the long-term consequences of repetitive head impacts across all contact sports, including rugby, soccer, American football, ice hockey and boxing," says Ann McKee at Boston University.

Éanna Falvey, the chief medical officer of World Rugby, said in a statement: "To date, we have invested over €10 million in welfare studies including the largest study into head impacts in community sport anywhere in the world and a study of health outcomes for over 3000 retired rugby players, both delivered in partnership with New Zealand Rugby. We will continue to build on this work in our quest to make our game as safe as it can possibly be for players at all levels within the rugby family." ▮

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Analysis Ecology

What is killing crustaceans on the UK coast?

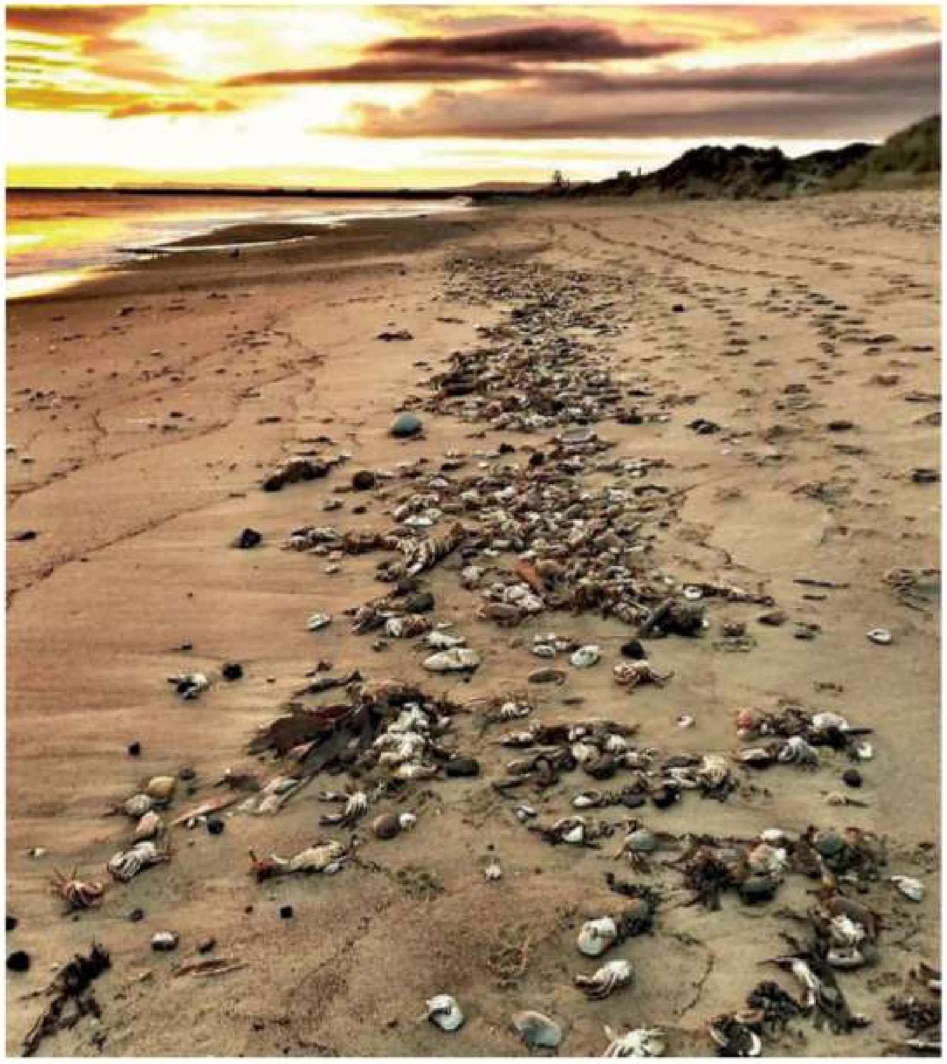
Pollution seems to be the most likely culprit behind the deaths in north-east England, reports **Jason Arunn Murugesu**

A MYSTERIOUS die-off of crustaceans on the north-east coast of England was probably caused by industrial pollution, according to a new study that contradicts the findings of a UK government report.

What is going on?

In October 2021, tens of thousands of dead and dying crabs and lobsters started washing up along the Tees estuary on the North Yorkshire coast and then further south in the fishing town of Whitby. The UK's Department for Food, Environment and Rural Affairs (Defra) launched an investigation into this in December 2021.

More dead crabs washed up on the coast in the region in February 2022. Fishing communities in Hartlepool told the BBC in June that they feared their businesses would fail due to a dramatic fall in catch numbers this year.



PAUL GRAINGER

Dead crabs on the beach at Seaton Carew, Hartlepool, in 2021

What is Defra's explanation?

In May 2022, Defra's report found that no single, consistent causative factor behind the deaths could be identified. But it pointed to a rapid increase in the population of algae, known as an algal bloom, identified in the region using satellite imagery. The report also found that it was unlikely that chemical pollution or the bioaccumulation of pyridine – which is used as an anti-corrosive treatment in marine infrastructure – had caused the deaths.

What does the new study say?

John Bothwell at the University of Durham, UK, says that he didn't totally believe the findings of Defra's report. "The evidence for the deaths [collected by Defra] was circumstantial," he says.

"It's not consistent with the patterns of mortality that you normally see with algal blooms," says Bothwell. "It doesn't normally preferentially affect crabs."

He reached out to the North East Fishing Collective and together they raised £30,000 to commission an independent study. Bothwell and his colleagues collected samples of water and dead crabs from the region and tested the effects of pyridine on crabs. They also modelled the effects of dredging on contaminating water bodies with pollutants.

The findings, which have been sent to Defra but not yet published, argue that the deaths of the crabs and lobsters probably weren't caused by an algal bloom and may be better explained by pyridine pollution.

> "The dead crabs had a high concentration of pyridine present in their systems"

The researchers found a high concentration of this chemical in the sediment off the coast and the dead crabs also had a high concentration of it in their systems. They also found that pyridine causes twitching behaviours in the crustaceans before death, which is similar to observations made about the dying animals earlier in the year.

Bothwell says that the high levels of the chemical don't necessarily mean that it actually killed the crabs and lobsters. "Pyridine could be a marker of something else," he says. "There could be a number of factors combining here."

Where has the pyridine pollution come from?

The source of high levels of this chemical in the water is unclear, but Bothwell says there are industrial plants in the region that produce it, which could be responsible.

The mouth of the river Tees was dredged in September and October 2021 to maintain channel depths at nearby ports. This material was then dumped into the water and may have contained contaminants, according to Bothwell.

Last month, more dredging work began to clear space for the new Teesside Freeport, which will cover an area of around 1800 hectares.

In August 2022, conservation charity the Royal Society for the Protection of Birds called on the government to stop dredging the Tees estuary until a scientific analysis had been conducted to rule it out as the reason behind crustacean deaths in the north-east.

How has Defra responded?

"We recognise the concerns in regards to dredging, but we found no evidence to suggest this was a likely cause ," says a Defra spokesperson. "There have been no materials licensed for disposal at sea in the area which would fail to meet international standards. This is a complex scientific issue, which is why we took a thorough, evidence-based approach. We welcome research carried out by universities and will continue to work with them, including studying this report carefully." ▮

Cognition

Musical game could boost your memory

PLAYING a rhythm-based game helps non-musicians become better at remembering recently seen faces. This hints that learning to play an instrument could improve short-term memory.

Theodore Zanto at the University of California, San Francisco, and his colleagues randomly assigned 47 non-musicians, aged between 60 and 79, to play either a tablet-based game that emulates learning to hit a drum in time with a teacher, or a word search game for eight weeks.

At the start and end of the eight weeks, participants took a short-term memory test to measure their ability to remember a face they saw seconds before. Only the group who played the rhythm-based game improved – by around 4 per cent (*PNAS*, doi.org/gqxkfk).

Alex Wilkins

Chemistry

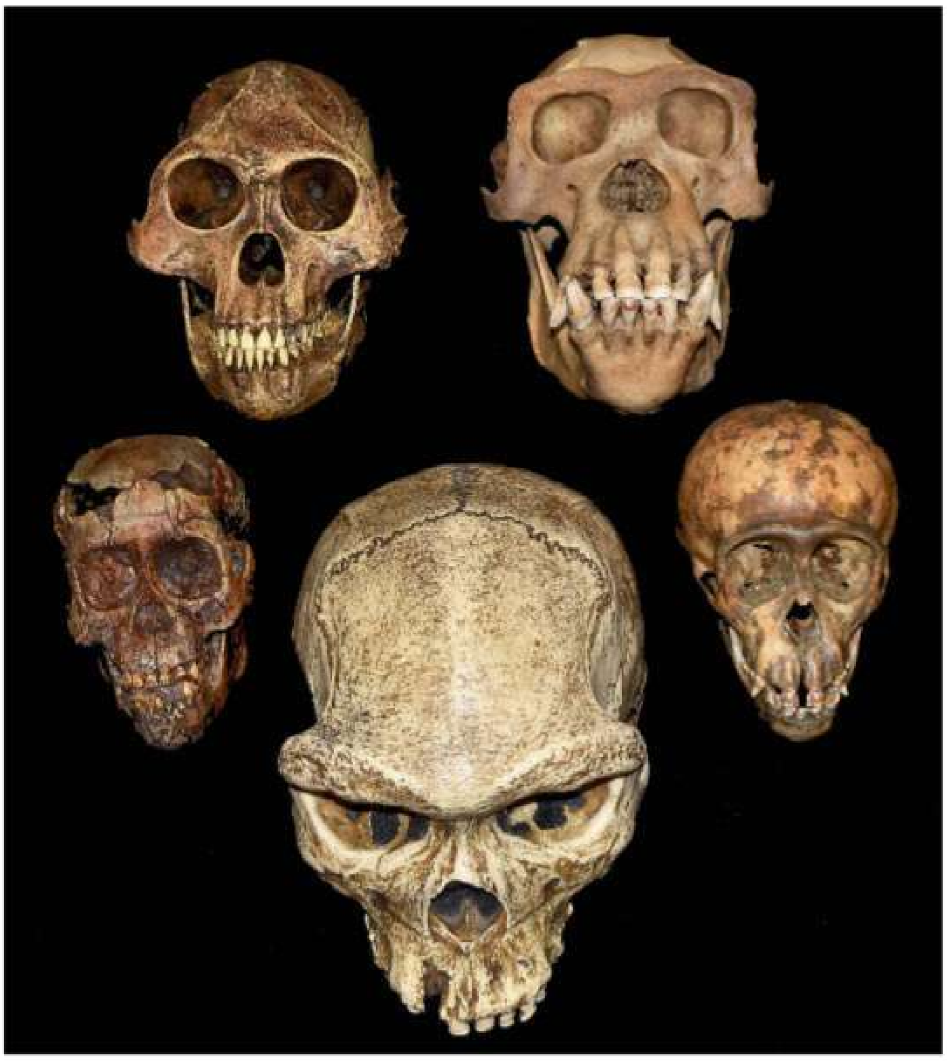
How molecules essential to life arose

A SERIES of experiments hint at how an energy-storing molecule found in all living cells could have first arisen on Earth.

All living things use adenosine triphosphate (ATP) as a source of energy for biological processes. As it is universal, it probably formed in the earliest stages of the origins of life. It is a precursor to RNA and DNA, so had it formed that early, it would have been a meaningful step towards life as we know it.

Silvana Pinna at the University of Strasbourg in France and her team have now shown that charged iron atoms and two molecules called adenosine diphosphate (ADP) and acetyl phosphate (AcP) have an arrangement of atoms uniquely suited for making ATP. They say this suggests it was this mix that contributed to the formation of life (*PLoS Biology*, doi.org/gqxnn5).

Karmela Padavic-Callaghan



TESLA MONSON

Human evolution

Our prenatal growth sped up after split from chimps

HIGH prenatal growth rates found in modern people may have first evolved in ancient hominids less than a million years ago, according to estimates based on fossil teeth.

Human fetuses grow by around 11.6 grams per day on average – much faster than the fetuses of gorillas, the next fastest ape, with a rate of 8.2 grams per day.

"We found that human-like gestation [may have] preceded the evolution of the [modern human] species – around 200,000 to 300,000 years ago – and may in fact be a critical factor that led to our evolution, particularly our large brains," says Tesla Monson at Western Washington University.

Monson and her colleagues found that across primates, prenatal growth rates are closely correlated with the ratio of the lengths of the first and third molar teeth.

The researchers built a mathematical model that could predict prenatal growth rates from the size of molars from 608 primates, including apes and African and Asian monkeys.

They then used the model to predict the prenatal growth rates of 13 hominid species from their fossil molar teeth. This revealed that hominid prenatal growth rates increased after our lineage split from chimpanzees around 5 to 6 million years ago, becoming more similar to those of modern humans around 1 million years ago (*PNAS*, doi.org/gqxnck).

The estimated rise in prenatal growth rates over this period coincides with increases in pelvis size and brain size among hominids. "It's really cool that our reconstructions align with so many other lines of evidence," says Monson. **Carissa Wong**

Really brief

REFLEXPERIENCE/SHUTTERSTOCK

Silk made tougher than spider webs

Dissolving silkworm silk and remaking it in a bath of sugar and ions of zinc and iron has made it stronger than most spider silks, one of the strongest materials in nature. The average force the new silks could take without stretching was 70 per cent higher than the average for spider silks (*Matter*, doi.org/jf3k).

Invisible contrails affect clouds

Streaks of invisible air pollution from shipping are changing the reflectivity of clouds. This means clouds exposed to air pollution from many sources may reflect more of the sun's light and heat than we thought, which will have to be taken into account in future climate models (*Nature*, doi.org/jf3p).

Making shift work more palatable

Shift work disrupts our cycles of sleep and waking, leading to an increased risk of diabetes, cardiovascular disease and cancer. But restricting eating to a 10-hour period within a 24-hour shift can counteract this, according to a study in firefighters (*Cell Metabolism*, doi.org/gqxnbg).

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Welcome to our Signal Boost project – a page for charitable organisations to get their message out to a global audience, free of charge. Today, a message from **Flynne's Barn**

"I can't think of a setting more inspiring than Thorneythwaite, nestled among the mountains and wide open skies. The farm is a haven of peace and tranquillity. Connection with art, with nature and with each other can really help young people to feel more fulfilled, more in control and more like themselves again."
Dr Sian Macfie

For young people living with cancer...

Flynne's Barn is a charity for young people living with cancer. Based in the Borrowdale valley, in the heart of the Lake District, Flynne's Barn supports young people and their families through residential group stays, counselling, creative activities and outdoor experiences.

Studies have highlighted the importance of addressing the psychosocial needs of young people following a cancer diagnosis (Clic Sargent, 2017; Teenage Cancer Trust, 2016). The positive impact of peer support groups, expressive therapies and opportunities to connect with others who have similar experiences of cancer is now widely recognised. There is also increasing evidence (White et al, 2021) for the mental health benefits of simple access to green/blue spaces.

Flynne's Barn is surrounded by fields, mountains and ancient woodland. The restorative effects of nature combined with the welcoming and peaceful space in the barn have a palpable effect on those who come to stay. We offer a wide range of immersive outdoor and creative experiences that encourage relaxation, connection and camaraderie. The aim is to meet with others, have fun and help each other along a challenging road.

During COVID-19 when residential visits were put on hold and it was difficult for young people to access support, we secured funding from the National Lottery Community Fund in order to set up a dedicated telephone and online counselling service. Our current referrals are mostly from Principal Treatment Centres in the North West and we are now expanding the service to other areas in the UK.

Want to help?

Flynne's Barn is growing, with more referrals for both its residential and counselling activities. To find out more or to help us to fund these services, check out our website flynnesbarn.org. You can also contact us if you are able to support our work in other ways info@flynnesbarn.org. Thank you.

Do you need your signal boosted?
If you are a charitable organisation working in STEM, science, medicine, technology or conservation, and would like to find out more about this project contact Jacqui McCarron on jacqui.mccarron@newscientist.com

Views

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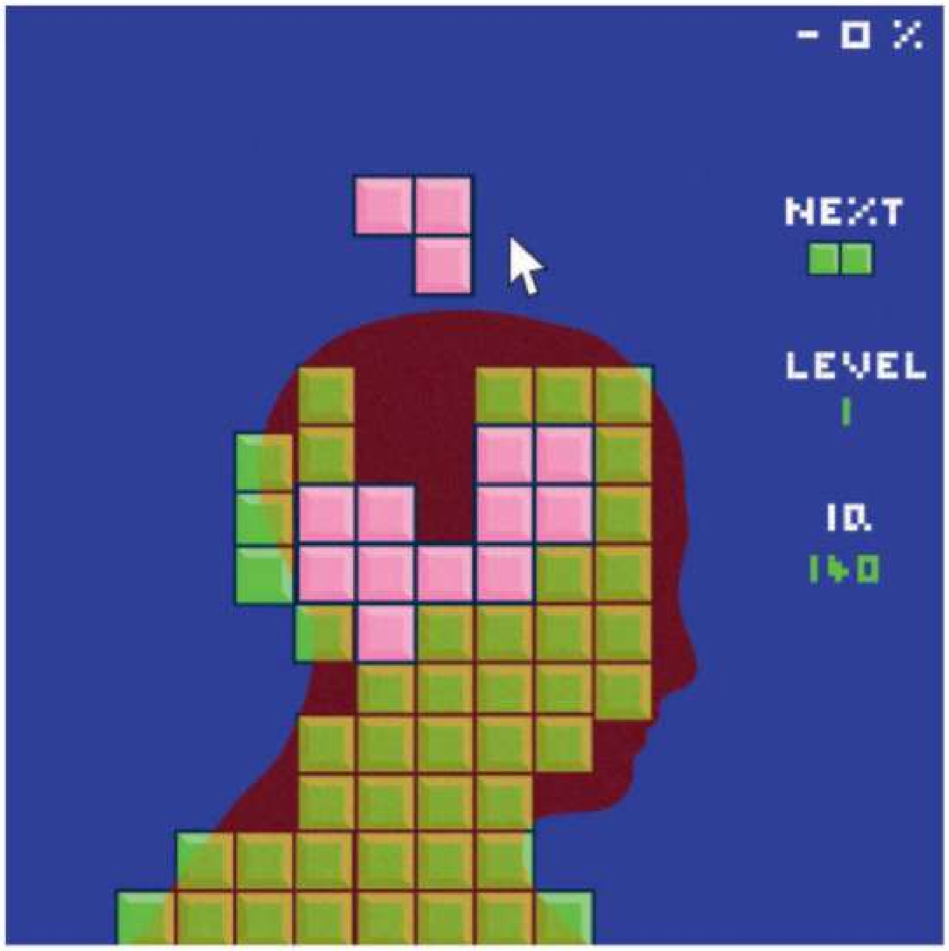
Culture columnist
Jacob Aron smashes space junk in a new video game p36

Comment

There's no app for that

Brain training apps claim to make us smarter, but there is no evidence for this – and they just aren't much fun to play, says **Adrian Hon**



MICHELLE D'URBANO

WOULD you turn down the chance to become a genius? We have long been fascinated by quick fixes that could increase our intelligence, not only in science fiction like *Flowers for Algernon* and *Limitless*, but in "smart drugs" like modafinil, a treatment for sleep conditions that some erroneously believe can make us smarter. Today, people's hopes lie in brain training apps as a speedy "digital pill", some of which claim to result in "smarter minds". But is this quick fix all it is cracked up to be?

There are plenty of brain training apps, mostly on smartphones, but they all share the same characteristics: they turn mental exercises like simple arithmetic, memory tests and logic and pattern-matching problems into quick games. The more you play these mini-games, the smarter you will get – or so some apps tell us. It is an alluring promise: instead of hard study or drugs, you just need to play a few fun games every day.

The use of game mechanics for serious purposes, or "gamification", has become widespread with the advent of the internet and smartphones. Brain training apps are at the fore, frequently featured by Apple and Google's app stores.

Many of the apps say they are backed by "science", a claim I found surprising as a former neuroscientist. Even if there were consensus around what constitutes general intelligence (which there isn't), the notion that increasing it would be as simple as practising a few mini-games every day flies in the face of what we have discovered about how humans think and learn.

Several major studies of brain training apps, surveying a diverse spread of thousands of users across a wide variety of apps, have found that they have little to no effect on users' performance. A 2021 study by researchers at Western University in Canada discovered that "brain training has no appreciable effect on cognitive functioning in the 'real world', even after extensive training periods". The positive effects that have been found are limited to the very specific mini-games and tasks that users are trained on, such as the ability to memorise lists of words or numbers, or perform mental arithmetic, with little transferability to other skills.

So, if your career or your calling in life involves being able to do sums quickly or remember all your friends' phone numbers, you may be satisfied with these apps. But if you are expecting them to improve your ability to write a novel or construct a complex spreadsheet, I am afraid you will want to look elsewhere.

Yet despite the lack of strong evidence that they work, brain training apps continue to flourish, partly because of their misleading invocation of "science" and partly because users think they will be fun.

As a co-creator of one of the most popular forms of gamification (*Zombies, Run!*, a smartphone fitness game), what is especially disappointing about these apps is that they just aren't that fun – at least, not compared with the endless variety of thoughtful board games and video games released every day.

Puzzle video games such as *Baba Is You* and *Into the Breach*, as well as detective games like *Return of the Obra Dinn* and *Her Story*, see players exert their skill at logic, memory and concentration in a far more complex way than any brain training mini-game. And if you aren't into games, simply going for a walk or learning how to dance is likely to be more effective than a brain training app in keeping your mind sharp as you age.

These activities might not promise to increase your intelligence, but I can promise they will engage your brain deeply while having fun – which is something I can't say of brain training gamification. ▮

Adrian Hon is the author of *You've Been Played* and the CEO and founder of Six to Start

This changes everything

Robot visions The success of text-to-image AIs raises major ethical issues, from the data sets they are trained on to the lack of compensation for artists, says **Annalee Newitz**

Annalee Newitz is a science journalist and author. Their latest novel is *The Future of Another Timeline* and they are the co-host of the Hugo-winning podcast *Our Opinions Are Correct*. You can follow them @annaleen and their website is **techsploitation.com**

Annalee's week

What I'm reading

The X-Men: New Mutants *comics, in which Cerebella finally gets her body back after being a brain in a jar for years.*

What I'm watching

The cheesy, melodramatic, so-bad-it's-good series Anne Rice's Interview with the Vampire.

What I'm working on

Trying to understand decentralised autonomous organisations, or DAOs.

This column appears monthly. Up next week: Wild Wild Life

IT ALL started when I typed a perfectly reasonable prompt into Midjourney, one of several apps on the market that can create an image based on text. "Skull space laser dinosaur starship explosion," I wrote. Midjourney processed for a few seconds, and returned four images, one of which was strangely accurate: a dinosaur-looking skull screamed out of the void of space, trailing fire. It resembled an illustration from *Heavy Metal* magazine, and perhaps art from the magazine influenced its creation.

You see, Midjourney and similar products like DALL-E, Stable Diffusion and Make-A-Video work their magic – translating words into pictures or video – by using vast "training data sets" of images scraped from the internet. It is very possible that Midjourney partly honed its craft by consuming *Heavy Metal* comics, pretty much the way I did as a kid. But unlike 12-year-old me, Midjourney didn't know what it was seeing. It relied on millions of unsuspecting humans for that.

Text-to-image AIs identify images by looking at the text that people have used to describe those pictures online. When Midjourney got my prompt, it contemplated images that random people had described as "dinosaur" or "laser" and so on, then used what is called a diffusion model to add a bunch of random chaos to those pictures. Once they were suitably scrambled, Midjourney "upscaled" them, removing noise and sharpening focus. Its work is so good that an artist using it recently won first place for digital images at the Colorado State Fair.

But there are major ethical issues raised by the success of such AIs. The biggest has to do with those training data sets. Reporters at Motherboard recently discovered that the data set used by Stable Diffusion contained images of terrorist violence and revenge pornography. When they prompted Stable Diffusion with the words "ISIS execution", the algorithm returned pictures that resembled real-life beheadings. Using an online tool called Have I Been Trained?, anyone can search the data set that Stable Diffusion uses, LAION-5B. That is how the reporters discovered Stable Diffusion was training on a data set that contains actual photos of extreme violence.

> "What if a robot army starts churning out propaganda that can't be distinguished from reality?"

Google also uses a LAION data set for an AI called Imagen, which hasn't yet been released to the public. Both Google and Stability AI, which makes Stable Diffusion, told Motherboard they are working on ways to prevent the public from seeing images based on offensive and illegal pictures in the data set. A representative from LAION also noted that the images in its data set are "already available in the public internet on publicly available websites".

But even if this problem is fixed – or companies choose better data sets – there is still the question of all the other pictures online that are being transformed into AI-generated masterpieces. As many artists have pointed out, their work is being used without compensation. Adding insult to injury, an image-generating algorithm could replace artists entirely, creating illustrations and even movies by using data sets stocked with art ripped off from artists who post their work online.

Some AI researchers argue that their algorithms aren't stealing from artists so much as learning from them, just as human artists learn from each other. But a more ethical approach would be for companies to acknowledge their debt to artists and create a model of voluntary collective licensing, much like radio stations first did in radio's early days. Back then, musicians created groups like BMI to collectively license their music to radio stations – then BMI would pay artists based on how often their songs were played. Perhaps artists and art institutions today could form a "collecting society" that would allow companies to license their artwork en masse for data sets. Artists could be paid based on how often an algorithm trained on the data set produced an image for commercial use.

Assuming we can iron out the many issues with training data, there is also the problem of just how good these algorithms are at creating realistic images. What if an army of robots starts churning out propaganda that can't be distinguished from reality? But honestly, of all the potential harms of text-to-image AI systems, I think this is the least worrisome. People don't need propaganda to be "realistic" to fall for it – we fall for it all the time. The solution to propaganda is human moderation of our online communities, alongside better media education. In a sense, this is the solution to our data set problems, too.

To create ethical AI systems, we need to acknowledge the people whose work makes those systems so magical. We can't simply snarf up every image online – we need humans to curate those data sets and we need to pay them to do it. ■

More wind power is a smart thing

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Show time

Photographers Jonny Dovovan, Tim Boddy

THERE were some excellent objects: everything from a state-of-the art robot "dog" created by the geniuses at Boston Dynamics, via a Neanderthal hand axe, to some old-school potatoes with electrodes attached. There were some stunning lectures, tackling everything from the origin of life and consciousness, through dark matter, ultra-processed foods, climate change, faecal transplants and the role of science in government. One talk, on schools' day, featured what sounded like dangerously large explosions, regardless of how far you were from that particular stage. And there were some excellent people: scientists, academics, artists, space photographers, herbalists, farmers, technologists – and, of course, so many of you, our wonderful readers, who joined both in person and online.

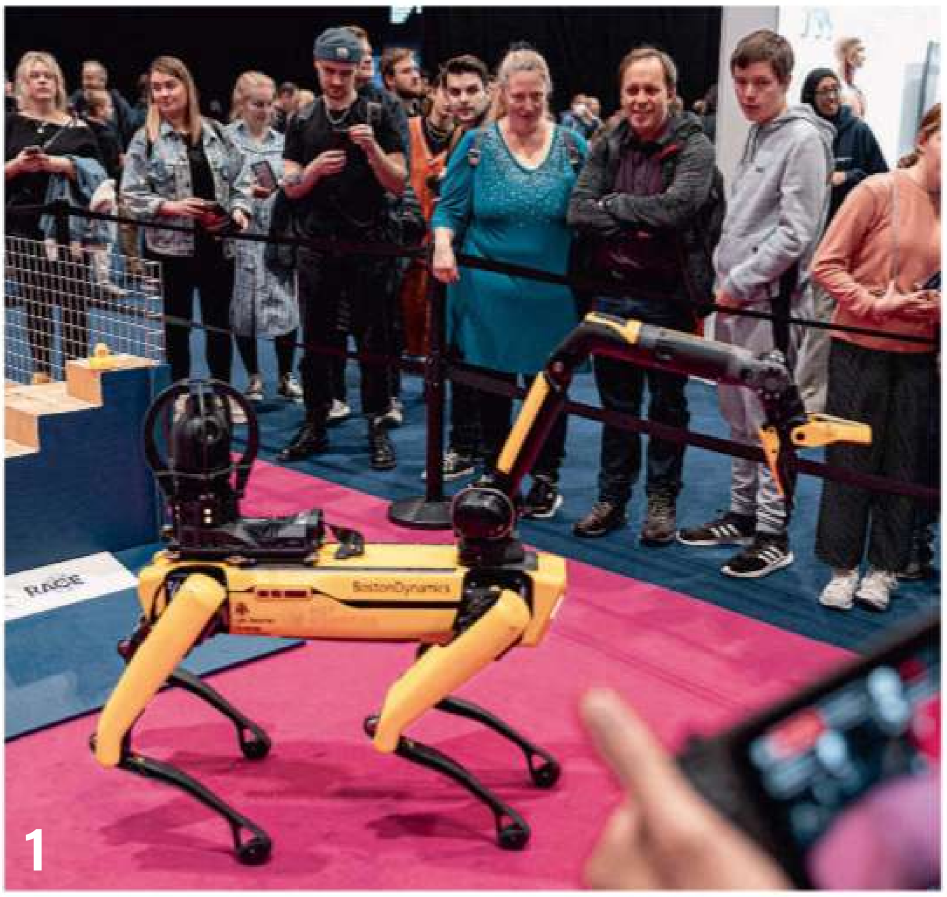
Yes, our flagship live event was back last weekend at the ExCeL London, after a pandemic-induced hiatus. I know, as the editor of *New Scientist*, you might think me horribly biased, but hand on heart, I loved every minute of it, and cannot wait to be back at the show next year.

The robot dog, by the way, was amazing to see in the wild rather than on a viral video. It was brought to the show by the UK Atomic Energy Authority, and its handlers told me the authority had bought four of them so far from Boston Dynamics. One of those is currently being tested in a radioactive space at Sellafield, the UK nuclear waste site, as proof of concept for the use of robots in such conditions. The authority has other robots, they said, but none that can walk upstairs, as the Spot class robot dogs can.

Another highlight for me was schools' day. We had many thousands of children at the show, which might sound like mayhem, but actually wasn't. The levels of engagement I witnessed, and the sheer love of science – both with the talks and with very interactive exhibits such as the Hospital of the Future created by King's College London – was heartwarming and extraordinary.

Anyway, we hope you enjoy these pictures from the show here and overleaf, and that you can join us on 7 and 8 October next year at New Scientist Live 2023!

Emily Wilson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1 The UK Atomic Energy Authority's robot dog performs for the crowds

2 Astronomer Royal Martin Rees asks if science can save the world

3 A visitor enjoys the John Deere tractor

4 J. Spooner in The Space Shed, performing their show "How I hacked my way into space"

5 Playing with virtual reality

6 Chris and Xand van Tulleken, stars of *Operation Ouch!*, meet a fan

7 A panoramic shot of the Engage stage, with Beth Knight talking about careers of the future ›

8

8 Watching Junaid Mubeen talk about the aspects of mathematical intelligence that distinguish humans from computers, on the Future stage

9 A close encounter with a Dalek

10 Exploring what can make you jump higher with Middlesex University

11 Taking a photo with the TARDIS

12 Chris Jackson speaks about geology on the Engage stage

13 Children investigate tropical diseases and the world of parasites with the Wellcome Centre for Integrative Parasitology

9

10

11

12

13

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Editor's pick

There is more to our pets than a bowl of food

24 September, p 44

From Marc Bekoff, Boulder, Colorado, US

"Meat-free mutts and moggies" is an interesting piece that covers a detailed study by Andrew Knight and his team. I think the simple answer to the question of whether dogs and cats can be healthy vegans is that we don't know.

However, what a dog or cat eats is only one of many factors that influence its quality of life. I have known many happy, healthy and long-lived vegan dogs, and a few cats. I have also known numerous omnivorous dogs and cats who lived unhealthy, short lives.

What we really need are comprehensive, multifactor studies focusing on individual dogs and cats, because their meal plans are usually dictated by human owners and are only one of many variables that factor into their quality of life.

Do I think dogs and cats can be healthy and happy vegans? I do, but other aspects of their lives have to be such that they are able to live happily when they aren't feeding, which constitutes the vast majority of their daily routines.

From vet Pete Wedderburn, Bray, County Wicklow, Ireland

While your article made a passing reference to insect-based food as an alternative to regular meat, but with a lower environmental impact, this deserved more focus. Insect-based foods, for example food made from black soldier fly larvae, seem far more suitable for pets than plant-based products, with a more palatable and more nutritionally complete profile.

Sad to see politics turning its back on environment

1 October, p 7

From Denis Watkins, St Just in Roseland, Cornwall, UK

"Rather than ramp up action to support our environment, this government appears, however, to be heading in the opposite direction," said Hilary McGrady, head of the UK's National Trust, as reported in your story on the UK government's plan to foster economic growth. These fears are echoed by many others.

Prominent figures in the government appear indifferent to environmental protection and dismissive of concerns raised. Until voters elect members of parliament who are committed to the environment, little will change.

Some tips if you have trouble getting to sleep

1 October, p 38

From Butch Dalrymple Smith, La Ciotat, France

You covered recent advances in treatment for insomnia. I have two secrets for nodding off to share.

When I was 8 years old, my older brother told me that complete relaxation in a darkened room for 5 hours is equivalent to 4 hours asleep. The important thing is to believe this, regardless of its truth. It eliminates the feeling of guilt, frustration and helplessness associated with lying awake.

The second tip is to learn to enjoy lying awake. I love reviewing the day and making plans – thinking about the boat I am going to build, for example – so I can't avoid falling comfortably asleep in a happy frame of mind.

Welcome clarity on what really shapes us

24 September, p 36

From Bob Denmark, Garstang, Lancashire, UK

Thank you to Clare Wilson for a very clear account of the latest research in the nature versus nurture debate. By the time my three kids hit their late teens, I concluded that their physical and psychological make-up was roughly one-third inherited, one-third due to the influence of family, friends and school, and one-third from outer space.

Now, my nine grandkids are in their late teens or early 20s, I haven't really changed that view, although I'm happy to swap outer space for the effect of randomness.

From Lee Seldon, Melbourne, Australia

I recall that all chemical processes in human brains – developing or developed, past, present and future – are subject to the laws of thermodynamics. That list would include gene expression, nutrition, neuronal and white matter growth and so on. Thermodynamics is a statistical description. In other words, it involves luck. That would indicate that "identical" twins may not be identical at the cellular level.

From Jon Arch, Welwyn Garden City, Hertfordshire, UK

Wilson's article on the role of randomness in shaping our children should be essential reading for parents and those who counsel them. It is a hard lesson to learn as we like to be in control.

Fusion power is far from near to being conquered

10 September, p 10

From Sam Edge, Ringwood, Hampshire, UK

I agree with Lee Margetts that fusion is an engineering problem, but to claim it is becoming well understood seems like hubris.

Rather than the 30-second reactor run you reported on, the most important recent advances are occurring in applying deep-learning systems to analyse plasmas, as previously covered in your magazine (26 February, p 19).

To go green, we need to ban lifestyle advertising

24 September, p 25

From Martin Murray, Telford, Shropshire, UK

I agree with Solitaire Townsend's call for green status signals, which are necessary to trigger behavioural changes that can address climate change. I can see several hurdles that will need to be overcome.

We must switch to a society where conspicuous giving and philanthropy are the main sources of status, but there are barriers to it in mainstream Western culture.

First up, lifestyle advertising. I can't see a way to avoid planetary collapse while we are immersed throughout our waking hours in a tide of advertising that links status to material purchases. It must go.

And public giving has to confer more status in our communities. We need a way to display the giving status of a person.

How to improve the equation for BMI

Letters, 1 October

From Hillary Shaw, Newport, Shropshire, UK

Reader Larry Stoter suggested the formula for body mass index needs a shake-up, perhaps being more like density, so based on the cube, rather than square, of height.

I have researched this: BMI was invented by Adolphe Quetelet. He stated that the proper power for height to determine BMI was 3 for babies (more spherical), 2 for teenagers (more like beanpoles) and 2.5 for adults.

In 2013, Nick Trefethen proposed the formula should be 1.3 times weight divided by height to the power of 2.5, which would keep BMI roughly where it is for people of average height, but raise it for shorter people and reduce it for taller people. ▮

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Grappling with long covid

This deep dive into what we know about long covid is welcome – but leans a little too heavily on anecdotal information, finds **Claire Ainsworth**

Book

The Long Covid Handbook

Gez Medinger and Danny Altmann

Cornerstone Press

ANDREW FOX/ALAMY

Long covid can shatter lives, stopping people from working

"The reality is really, really hard. And rather than try to put a positive spin on it in this book, I want to call out that reality and let you, the reader, know that if you're feeling this way, you're not alone." Gez Medinger, one of the authors of *The Long Covid Handbook*, describes the anger, grief and frustration felt by those with long covid, a poorly understood condition in which people who have had covid-19 experience debilitating symptoms that persist for three to four months and beyond. Their frustration underlies a major tension, felt in the book, that exists between people's need for an explanation and treatment for long covid – and other conditions with which it appears to overlap, such as myalgic encephalomyelitis or chronic fatigue syndrome – and science's failure, so far, to deliver definitive answers.

Long covid shatters people's lives. Symptoms such as fatigue, "brain fog", heart palpitations, joint and muscle pain, fainting, dizziness and allergic reactions means some of those with the condition can't work, or even get out of bed. Not knowing when or if they will recover adds to the burden on their mental health. The condition can strike young, healthy adults: Medinger used to run marathons before he got it.

Initial scepticism from parts of the medical community about the existence and nature of long covid has now transformed into acceptance, and the *BMJ* has just published an update for UK doctors on how to recognise and treat patients. But beyond sympathy and basic help with symptoms, there is little doctors can offer, although covid-19 vaccination can help. Now, Medinger and his co-author Danny Altmann, a professor of immunology at Imperial College London, have joined forces to explore what we know so far and bring it all together in one place.

This is no mean feat, especially if you have long covid, as Medinger still does. His voice is that of the first-hand expert – someone who has lived experience of the disease and who has been embedded in the long covid community for more than two years. He seeks to make sense of his condition, find ways to improve it and share his findings, both anecdotal and data-driven, with fellow patients: he has a YouTube channel where he has made 80 videos on the subject. Altmann, meanwhile, is the voice of conventional biomedical science. His role is to explain the complexities of scientific findings and act as wingman and sceptic.

Overall, this double act works well. There are chapters on the current thinking around what the mechanism is behind long covid, why some people get it and others don't, and how their symptoms arise. There is a welcome chapter dedicated to children with long covid, as well as helpful discussion of mental health and how to seek help. The book ends optimistically, describing upcoming research, including a major immunology study led by Altmann that seeks to tackle some of the questions raised in the book.

> **"Medinger seeks to make sense of his condition, find ways to improve it and share his findings"**

I am uneasy, however, at the extent to which Medinger relies on anecdotal information, which I would argue includes the patient surveys he has conducted himself, and his tendency, in places, to bat Altmann's caveats aside. There is a lot of speculation and some hair-raising stories of how Medinger has taken on the role of human guinea pig and tried treatments despite a lack of reliable clinical data: he was once hospitalised as a result of a severe adverse reaction to the antiparasitic drug ivermectin, for example. But in the absence of effective medical help, I sympathise with his situation.

As Altmann says, with the sudden appearance of a new, common condition and an agenda driven by patients rather than the medical establishment, we are in uncharted territory. The conventional clinical trial is sacrosanct, and for good reason, but he wonders whether science can find faster ways of getting trials done. Just look at how the world produced a covid-19 vaccine within 12 months – a process that usually takes years. "If this book can help to trigger some of those policy discussions about faster routes to trial and licensing, that would be a job well done," says Altmann. With long covid patients now numbering an estimated 150 million, we need to have those conversations sooner, rather than later. ▮

Claire Ainsworth is a science journalist based in Hampshire, UK

Translating the mind

A neuroscientist explores different interpretations of consciousness in this engaging, if a little repetitive, book, says **Jonathan R. Goodman**

Book

Nineteen Ways of Looking at Consciousness

Patrick House

Wildfire

TRANSLATION is a difficult task. Words mean different things to different people, not only between languages but within them. This is particularly true of difficult concepts in the arts and sciences: terms like altruism and love spur huge debates between people of all backgrounds.

Patrick House, a neuroscientist concerned with the mind, makes clear how far-reaching this issue is in his new book, *Nineteen Ways of Looking at Consciousness*. The "ways" are like different translations of the underlying concept of consciousness, writes House, and the number takes its inspiration from a 1987 series of 19 translations of Wang Wei's *Deer Park*, a poem where even the words for colours have ambiguous meaning.

House relies on this ambiguity of translation in his engaging discussion of what consciousness is. Is it a simulation? A narrative? An accidental consequence of the long evolutionary road we have taken? For House, it is all of these and none. What matters is how we look at consciousness, and the biases we take along the way.

As with other complex ideas, debate around what consciousness is, how the mind works and whether the mind and brain are separate isn't new. The mechanistic problems are, for the most part, of less concern to House than the overarching question of how we might define consciousness at all – and the tools we can and should use to do so.

In each chapter, he returns to the story of Anna, a teenager who laughed during brain surgery when a doctor artificially stimulated her neural activity. The story forms a kind of window through which we are meant to view these varying – and sometimes quite out-there – ideas of consciousness, such as whether it is actually a simulation, much like a video game. One approach sees him exploring the neurological events leading to Anna laughing; elsewhere, he uses the anecdote to examine how thoughts, feelings and language coevolved. Each way of looking at consciousness shares this understandable hook, and so the connection between the surgeon's stimulation and Anna's laughter is examined in 19 different ways.

House shows great ability as he translates these complex ideas – philosophical, neurophysiological and evolutionary – into simple language by adjusting his writing style between chapters and making good use of this deceptively simple example. I do have a few minor complaints, though. Because many of the ideas House discusses are so complex, and so old, their overlap can make the chapters seem a bit repetitive. We are, after all, covering a whole 19 ways of looking at consciousness. This makes it hard not to let out a groan when we hear about Anna's surgery for the fifteenth time, even if the perspective is new and interesting.

House also attempts to find an overarching explanation of consciousness that blends the hypotheses he discusses. Whether this is successful is a second and more challenging issue. At the outset, House invites us to think of something approaching the true translation of *Deer Park* – whatever that means – as a blend of the 19 translations presented in the 1980s. Consciousness may, analogously, be a combination of the 19 views that House presents. But whether that combination is possible – much as whether it is possible that one word in a poem simultaneously means green, blue and black – is left for the reader.

None of this, however, prevents *Nineteen Ways of Looking at Consciousness* from being an informative read that makes us look at ourselves and the human mind in a series of fascinating ways. ▮

Is consciousness a narrative? A simulation? An accidental consequence of evolution?

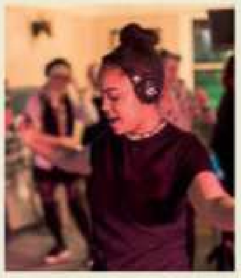
ORLA/SHUTTERSTOCK

Jonathan R. Goodman is at the Leverhulme Centre for Human Evolutionary Studies

Don't miss

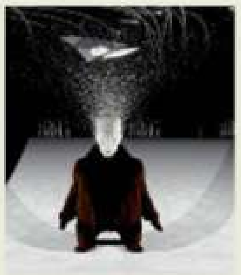
Visit

In Plain Sight exhibits art (example pictured), scientific and medical items as it explores sight via the experiences of sighted, blind and partially-sighted people. At the Wellcome Collection in London from 20 October.



Visit

Turn It Up: The power of music is an interactive exhibition looking at the science of music's hold over us and how technology is pushing its limits. Opens on 21 October at the Science and Industry Museum in Manchester, UK.



Visit

Cold Light by Lindsay Seers and Keith Sargent is inspired by the work of electricity pioneer Nikola Tesla. Featuring robots, VR and a sound installation, it will be at Turner Contemporary in Margate, UK, from 22 October.

FROM TOP: HELEN EPEGA AND THE ARTIST; SCIENCE MUSEUM; TATE

The games column

Breaking it down

Hardspace: Shipbreaker lets you work as a salvager stripping spacecraft for parts in low Earth orbit. Essentially, it is like building a Lego set in reverse, and, like Lego, it is a very satisfying experience, finds **Jacob Aron**

Jacob Aron is *New Scientist*'s news editor. Follow him on Twitter @jjaron

BLACKBIRD INTERACTIVE/IGDB.COM

ARE you worried about machines coming for your job? Personally, I hope I have a few decades yet before science journalism is fully automated, though I admit the rapid progress of text-generating artificial intelligence has me a little concerned. Now, thanks to *Hardspace: Shipbreaker*, I already have an alternative career lined up: spacecraft disposal technician.

The game, which was released on PC in May and received a wider console release in September, is set in the 24th century, when Earth has become a hellhole and much of humanity lives elsewhere in the solar system. In an effort to get off-world, you sign up with Lynx, a corporation in the grand tradition of evil sci-fi conglomerates, where you start work as a "shipbreaker" – a salvager who strips spacecraft for parts in low Earth orbit.

There is a strong anti-capitalist message from the get-go, when you are forced to sign up for the Lynx Everwork Asset Replacement programme. This sees your body scanned and cloned, with the original destroyed. Shipbreaking is a dangerous business, but, thanks to Lynx, when you inevitably have a fatal accident the company will simply spin up a new version of you in a vat.

For this, and other privileges of working for Lynx, you take on $1.2 billion of debt. That isn't quite as bad as it sounds: assuming inflation averages the same for the next few centuries as it has for the past few, you are looking at about $40 million in today's money. That is roughly what it costs for a short joyride to orbit with Blue Origin, let alone being cloned and becoming functionally immortal.

> **"There are exciting ways to die, from forgetting to top up your oxygen to crashing into a chunk of spacecraft"**

My first shift involved getting used to moving around in zero gravity. Your suit has the ability to thrust and rotate in every direction, so it is easy to get upside down and disoriented. The game cheats slightly here when it comes to the physics of zero-*g*: Newton's laws say you should continue at the same velocity forever after getting in motion, but you will eventually come to a halt in the game if you ease off the thruster. However, this is a reasonable choice to save you from flying off into deep space.

> **If you cut into a ship with an atmosphere, you risk explosive decompression**

Once I had navigation sorted, it was time to learn the tools of the trade: the cutter and the grabber. Spacecraft are welded together at cutting points that you burn through, then you use your grabber to pick up the pieces and deposit them in one of three locations on your space dock: a furnace, for general rubbish; a processor, for material that can be recycled; and a barge, to hold high-value objects such as engines. Put something in the wrong place, and you will diminish your pay at the end of the shift.

Essentially, the game is like building a Lego set in reverse as you carefully peel off and sort parts, and, like Lego, it is a very satisfying experience. Unlike Lego, there are a lot of hazards to deal with. If a ship is pressurised with an atmosphere, you can't simply cut into it – or rather you can, but then you run the risk of explosive decompression. If you cut a fuel line, you also risk an explosion. Oh, and then there are the nuclear reactors that power each craft.

There are other exciting ways to die, from forgetting to top up your oxygen to crashing into a chunk of spacecraft and busting your helmet open, but as I grew more experienced I was dying less and less often. It actually feels like learning a craft because after some practice I found it easier to eye up the best – and safest – way into a ship to get the most valuable goodies. My next career awaits. ▮

Game

Hardspace: Shipbreaker

Blackbird Interactive

PC, PlayStation 5, Xbox Series S/X

Jacob also recommends...

Games

Viscera Cleanup Detail

RuneStorm

PC

Imagine fighting aliens on a space station. Now imagine being the person who has to clean up the mess. That is the idea behind this funny and slightly surreal game.

PowerWash Simulator

Futurlab

PC, Xbox One and Series S/X

For a more mundane job, pick up a power washer and blast away at grime on cars, gardens and more, ideally while neglecting to do any cleaning in the real world.

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Jobs

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*Source: Google Analysis Jan-Dec 2021

How to be curious

Curiosity can be a boon and a bane by turns. The secret is to know when to let it loose and when to keep it in check, says **Dan Jones**

DURING an icy April in 1626, Francis Bacon, philosopher and a pioneer of the scientific method, was riding through the snowy streets of London when a curious question popped into his mind: would the cold help preserve a dead chicken? After acquiring one from a nearby household, he set about stuffing the bird with snow. In the process, he caught a chill, quickly followed by pneumonia and death.

This possibly apocryphal story, spread by philosopher Thomas Hobbes, points to two faces of curiosity: one a virtue, the other a vice. Curiosity is the driving force behind science, exploration and discovery, in which form it has been as important in our species' success as our intelligence. Curiosity can also be a boon to us individually, guiding us into passionate, purpose-filled lives – think of relentlessly curious people like Leonardo da Vinci.

But "the lust of the mind", as Hobbes dubbed curiosity, turns vice-like when it leads us to waste time on clickbait and fake news, doomscroll through social media feeds or chase dangerously extreme experiences, like jumping from tall objects with a parachute, simply because we want to know what they feel like. It can end badly. Just recall the infamous, now-deceased cat.

In a modern world awash with many such diversions, it would be good to know how to make the most of our curiosity while avoiding its pitfalls. Recent research on the double-edged nature of curiosity is riding to the rescue. The work hasn't only shed light on its many benefits for learning and creativity, but also on the reasons that it can lead us astray – and why we should sometimes seek to curb our curiosity.

While curiosity is undoubtedly a complex psychological state, most researchers broadly define it as a drive to know things and gather information about the world – something that all organisms need to do. "Information is as fundamental for life as energy," says cognitive neuroscientist Jacqueline Gottlieb of Columbia University, New York. "A nematode worm or amoeba gathering information about its environment, like where it can find food, shows curiosity, even if it's a very limited and immediate kind."

Curiosity in humans – the planet's preeminent "infovores" – can be more expansive, open-ended and powerful. But, at its most basic level, our hunt for information is sparked by a desire to deal with uncertainty, by seeking meaningful patterns in our surroundings.

Recent research suggests that this is particularly important for babies and children navigating their brave new world. Celeste Kidd, a psychologist at the University of California, Berkeley, has devised a series of visual scenes of varying predictability. These videos showed objects like toy fire engines being momentarily hidden by a screen that was repeatedly dropped and raised in front of it. Each time the screen lifted, the object would be present with a certain probability. In some cases, the object was almost always present,

ADAM NICKEL

“There is a sweet spot between predictability and uncertainty that piques our curiosity”

making the sequence very predictable, while in other cases the chance of it reappearing was much more random, with low predictability. They also saw scenarios in between.

Kidd then measured participants’ attention with eye-tracking tools to find out exactly where they were looking. In children as young as 7 months old, she found that sequences of intermediate predictability elicited more visual exploration than either tediously predictable or confusingly random sequences.

Kidd describes this sweet spot between predictability and uncertainty as the Goldilocks effect. It makes sense, because it is the relatively unpredictable – but not totally regular or completely erratic – situations that offer the most useful opportunities to learn something about the world around us. Just consider social norms of behaviour – they tend to follow some regular rules, but with a lot of variation, and curiosity about those irregularities will make it easier to navigate similar situations in the future.

In July this year, Kidd reported finding the same patterns in rhesus macaque monkeys. “We seem to have this built-in mechanism that seeks out information with just the right amount of uncertainty so that we can integrate it with our existing understanding of the world,” she says.

As we grow up, humans are soon interested in much more than their immediate environment, of course – we can become deeply fascinated by abstract topics, such as mathematics or philosophy. Often, the objects of our

›

curiosity may have little immediate use in our lives. “We spend a lot of time getting information without knowing its value,” says Gottlieb. In many cases, the best way to measure this interest is by simply asking people how curious they feel to learn a particular fact or subject.

According to one influential idea, we are particularly curious when we face an “information gap” – some unsolved mystery or unanswered question. In much the same way that those visual scenes for children needed to have the Goldilocks level of predictability and uncertainty to grab their attention, the size of the information gap matters. If it is too big, the question or topic feels unmanageable and daunting; too small, and it feels like irrelevant minutiae best ignored. We are most curious about stuff that falls somewhere between the two – something that is surprising and useful, but not wholly unfamiliar.

Finding that balance will be crucial for learners and their teachers. Numerous studies have shown that the more curious people feel

Humanity’s insatiable desire to explore led us to the moon

NASA

Morbid curiosity

Our urge to know when confronted by uncertainty can take a morbid turn, leading us to dark and even painful places.

In a study published in 2016, people were presented with a range of coloured pens and told that some colours would deliver an electric shock when clicked, some wouldn’t and others may or may not give a shock. Left to their own devices, people were more likely to click the uncertain colours to find out. Getting a shock was a price they were willing to pay to resolve the uncertainty.

As our appetite for horror films and grisly crime shows reveals, we also seem to be curious about unpleasant things. Suzanne Oosterwijk at the University of Amsterdam in the Netherlands has found that people often prefer to look at negative images depicting gore or death over neutral images, and that viewing negative content can even activate reward circuits in the brain.

In moderation, this tendency may have a purpose. “Morbid curiosity can help us mentally prepare for bad things, should they happen to us,” says Oosterwijk. At its extreme, however, it can lead us into compulsive and potentially damaging doomscrolling, endlessly surfing social media for stories that can leave us anxious and depressed.

This issue became particularly stark during the first two years of the covid-19 pandemic. People were extremely curious about covid-19, and surveys found that increased use of social media and viewing of covid-related news was linked to greater psychological distress. Consuming just a few minutes of negative covid-related news – browsing through Twitter feeds of covid-focused accounts or watching YouTube videos on the subject – was found to increase negative feelings and decrease well-being, though these effects could be offset to a degree by viewing good-news stories.

We are often willing to undergo pain and distress in our hunt for new knowledge

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What is your curiosity profile?

Psychologist Todd Kashdan at George Mason University in Virginia has recently proposed there are five dimensions of curiosity, each reflecting different ways that our interest in the world can be experienced (see main text). These are deprivation sensitivity (the need to find answers to specific questions), joyous exploration (a general love of learning), stress tolerance (the capacity to withstand the anxiety provoked by the unknown), thrill-seeking (the willingness to take risks for novel experiences) and social curiosity (an interest in learning from others).

Applying this model to 3000 survey respondents, Kashdan has identified four curiosity profiles defined by distinct patterns of these dimensional ratings. Roughly 28 per cent of people are labelled "fascinated" – they rate high on joyous exploration and stress tolerance, read the most magazines and websites, have the most passions, have the most friends and earn the most money.

Another 28 per cent are "problem solvers", scoring higher than other people on deprivation sensitivity, but also high on stress tolerance and low on social curiosity. Problem solvers might prefer to tackle a crossword than ask someone about their life, but they can direct their curiosity to specific interests with great intensity.

"Empathisers", making up 25 per cent of people, have high levels of social curiosity, but low levels of stress tolerance and thrill-seeking. The most agreeable of the curiosity profiles, empathisers are more likely to be women and typically have large online social networks.

The smallest group, at 19 per cent, are known as "avoiders". They rate lower on every dimension than every other group (except social curiosity, which is lower in problem solvers). Avoiders are the least educated, have the fewest passions, have the smallest social circles and make the least money.

> **"Curiosity warms up circuits including the hippocampus to prepare the brain to learn"**

about getting the answer to a trivia question, the better they remember the fact. And by asking people to report their own curiosity while they viewed different facts in a brain scanner, Matthias Gruber at Cardiff University, UK, has discovered the reasons why this is so.

In Gruber's model, curiosity begins with some kind of uncertainty or information gap that activates the hippocampus – which, along with its role in memory, also detects novel stimuli – and the anterior cingulate cortex, which monitors informational mismatches in the brain. The brain then appraises how rewarding it will be to fill in the hole in its knowledge, which shows up as activity in the prefrontal cortex.

This last step is where the most variation between people is seen. "The same stimuli could elicit different degrees of curiosity, no curiosity at all or even anxiety about the uncertainty or novelty," says Gruber.

If that appraisal is positive, we enter a state of curiosity that activates the dopaminergic circuit in the brain related to reward processing and memory. This also tags information encountered while curious as especially salient, which helps form stronger memories. "Curiosity warms up these circuits and the hippocampus to prepare the brain to learn and create long-term memories," says Gruber.

His research has found that these benefits spill over to other incidental information presented at the same time as the objects of their fascination. If participants were shown a trivia fact that had aroused their curiosity, alongside a photo of a face, for example, they were much more likely to recognise that person later on – even though it had nothing to do with the information that had first sparked their interest.

Chasing clickbait

Beyond memory, curiosity may also drive creativity: various studies suggest the two traits are moderately correlated. The causal link remains an open question, but curiosity might jump start creativity by motivating us to gather information and explore novel things. This makes us more likely to encounter facts, ideas and ways of thinking that could generate new insights or solutions to vexing problems.

With the prospect of a supercharged memory and a flair for innovation, you might think that deliberately cultivating your curiosity would be a no-brainer. Yet multiple experiments show that it also has some downsides.

The most obvious are distraction and time-wasting. Clickbait headlines, like "You won't believe what happened next!", exploit information gaps. And for many people, the › desire to close these gaps can be so strong that they can't resist clicking, even if the topic isn't of particular importance and even if it may lead to untrustworthy information.

To explore this idea, psychologists have developed ways to measure our desire to fill information gaps. One common tool is a questionnaire that asks you to rate sentences such as "I work like a fiend at problems that I feel must be solved" – a tendency that is assumed to be driven by curiosity about the potential answer.

Such tendencies can be a bit of a red flag. A study published in June this year by Claire Zedelius at the University of California, Santa Barbara, and her colleagues found that people who scored highly on these scales were prone to score worse on measures of general knowledge. They were also more receptive to fake news and other forms of "bullshit" (yes, that is the scientific term). They were at a higher risk of believing a purported news story about a plane that had "disappeared and landed 37 years later", for example, or a claim that former US president Barack Obama had been arrested for espionage. They were also more likely to say they found meaning in pseudo-profound sentences such as "attention and intention are the mechanics of manifestation", which has no logical sense. Overall, the participants who showed a great desire to resolve unanswered questions just weren't very discriminating in the information they were willing to consume.

Five dimensions of curiosity

Then there is curiosity's capacity to lead us down dark and depressing avenues – something that may be particularly harmful when trying to cope with difficult situations like the covid-19 pandemic (see "Morbid curiosity", page 40).

Such complexities have led some researchers to argue for a more nuanced approach that considers the many ways that Hobbes's "lust of the mind" can be expressed. Todd Kashdan, a psychologist at George Mason University in Virginia, has led the way by developing a model that considers five "dimensions" that shape our curiosity.

One of these, "deprivation sensitivity", reflects our tendency to experience the mental itch when we encounter information gaps – the intense need to know an answer that leads us to solve problems and resolve mysteries. A second, "joyous exploration", describes a wider-ranging interest, experienced as a genuine pleasure in learning about new subjects and thinking about things in depth.

Are kids really more curious than adults?

Human curiosity is evident in our first interactions. Babies intently scan the world around them, and as soon as they can grasp, crawl and toddle, they will actively seek out new information by whatever means possible. Much of this curiosity-driven exploration is geared towards figuring out how things work or what they are for, says psychologist Tania Lombrozo at Princeton University, who studies curiosity in childhood. And then, once kids can talk, they can begin to tap other people's knowledge. "Kids start asking 'why?' questions as soon as they have the language to do so," says Lombrozo.

Conventional wisdom says our innate curiosity is quashed by the tedium of school and then the practical demands of adult life. But there is little hard evidence for that, says Lombrozo. Instead, curiosity seems to get expressed differently as we mature.

Lombrozo says that as we get older, we shift from an expansive, exploratory kind of curiosity to a style more geared towards gaining information towards a specific end. "As adults, when we have to accomplish certain kinds of goals, we're usually better off immediately narrowing our attention," she says.

One downside is that our ideas can become too rigid and fixed, limiting our creativity. "Adults tend to construe an object, say a box, for its primary function, like storing stuff, and tend to think about using it in standard ways," says Lombrozo. "But sometimes an object might need to be used in a non-standard way to solve a problem. And it turns out that kids can outperform adults in these kinds of puzzles."

The trick, then, is to stay playful and curiously creative.

Children have wide-ranging interests, whereas adults are more focused on specific goals

ADRIAN SHERRATT/ALAMY

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Thrill-seeking is considered to be one of the five dimensions of curiosity

ALEX RATSON/GETTY IMAGES

Together, these two dimensions cover the epistemic curiosity that was traditionally the topic of psychological study. But Kashdan goes further. He considers "stress tolerance", for instance, which is your ability "to accept the anxiety that is a natural part of confronting the new", he says. This takes into account the fact that some people's anxiety can lead them to shy away from the unknown, while others manage those feelings more successfully. "Often, people would like to explore something, but they don't feel able to handle what that involves", he says.

Related to this, Kashdan also cites "thrill-seeking" as a factor – whether "you would take serious health, financial, legal or social risks to acquire novel experiences", he says. Someone who leans strongly this way would take any opportunity to do something new. The final dimension, "social curiosity", concerns our willingness to learn from other people.

There now seems little doubt that the distinction between the first two factors is crucial in understanding curiosity's true effects, for good and bad. In studies on curiosity and creativity, "joyous exploration" is more than twice as strongly correlated with creativity than "deprivation sensitivity". And in the studies on misinformation led by Zedelius, it was people who scored high on deprivation sensitivity who were more likely to fall for fake news and bullshit, while those high in joyous exploration didn't seem prone to this.

Kashdan's own research, published in 2020, shows that these dimensions can determine different outcomes in the workplace. Higher levels of joyous exploration and stress tolerance offered the best predictors of innovation at work, while a combination of high stress tolerance and high social curiosity led to the greatest overall workplace engagement and job satisfaction. He has also demonstrated that people generally tend to fall into four distinct subgroups, depending on their scores on the different dimensions (see "What is your curiosity profile", page 41).

"Much of this is temperamental," says Kashdan. But that doesn't mean you can't try to nurture your curiosity in general – and joyous exploration in particular. Given that you are reading this magazine, you are already doing one of the most important things: opening yourself up to new ideas that may spur you to find out more and more. Keep it up, as you broaden and build your capacity for curiosity. You can try new foods, listen to new music, check out a new TV show or podcast or visit a new city. Talk to people and ask them questions.

> **"People who scored high for deprivation sensitivity were more likely to fall for fake news"**

Along the way, you can use these opportunities to build tolerance for the uncertainty that is inherently tied up with exploring unfamiliar topics and trying new experiences. You might also try to get over any embarrassment at showing your ignorance in front of people, suggests Kidd. "You need to develop tolerance for not knowing stuff, especially in a social domain, and become comfortable saying 'I don't understand what you mean' or 'I don't know how to do that'."

If you are feeling anxious about the unknown, and shying away from it as a result, you could try to reframe those feelings as excitement and view your ignorance as an opportunity for growth. As Gruber points out, a positive appraisal can make a big difference for the curiosity someone feels and expresses.

As long as you are mindful of the potential for distraction – and ensure that you feed your curiosity with intellectually nutritious sources of stimulation, rather than clickbait and fake news – these steps should lead you to greater happiness and fulfilment. "The good life, as most philosophers have argued, starts with knowing yourself and understanding your values and propensities, what makes you you," says Kashdan. "Curiosity opens up pathways that can really lead you to understand your primary sources of meaning and purpose in life." ▮

Dan Jones is a science writer based in Brighton, UK

DAVID STOCK

Do objects exist?

Michael Brooks took physicist **Carlo Rovelli** to the Tate Britain art gallery to find out what science and art can tell us about the nature of reality

CARLO ROVELLI stands in front of an exploding shed. Fragments of its walls and shattered contents – parts of a child's tricycle, a record player, a shredded Wellington boot – hang in mid-air behind him. I have come to meet the physicist and bestselling author at an exhibition at the Tate Britain art gallery in London. The scattered objects are the work of Cornelia Parker, one of the UK's most acclaimed contemporary artists, known for her large-scale installations that reconfigure everyday objects.

For Rovelli, based at Aix-Marseille University in France, Parker's work is meaningful because it mirrors his take on the nature of reality. "I connect with the process: of her coming up with the idea, producing the idea, telling us about the idea and of us reacting to it," he tells me. "We don't understand Cornelia Parker's work just by looking at it, and we don't understand reality just by looking at objects."

Rovelli is an advocate of an idea known as relational quantum mechanics, the upshot of which is that objects don't exist independently of each other. It is a concept that defies easy understanding, so Parker's reality-challenging exhibition seemed like it might be a helpful setting for a conversation about it – and about what else Rovelli is up to. It is a happy coincidence that Parker's shed is called *Cold Dark Matter*, a reference to the unidentified stuff that is thought to make up most of the universe. Because Rovelli now thinks he knows how we might finally pin down the true nature of dark matter.

The problems physicists such as Rovelli are trying to tackle are some of the deepest in science. Take the riddles related to quantum theory, our best guide to the subatomic world. It paints particles as occupying multiple possible states at once before they interact with other things. How to make sense of that?

New Scientist video
Watch the full interview with Carlo Rovelli at **youtube.com/newscientist**

It is also difficult to see how quantum theory fits with general relativity, Albert Einstein's theory of gravity, because the two theories require mutually incompatible mathematical frameworks to describe reality.

Rovelli formed his latest insights into how we might solve such problems when he began to dissect theoretical physicist Werner Heisenberg's 1925 trip to the small, treeless island of Helgoland in the North Sea. Here, Heisenberg dedicated himself to resolving the confusion created by his contemporary Erwin Schrödinger's description of quantum objects – electrons, neutrons, photons of light and so on – as waves that somehow manifest themselves to us as particles. Heisenberg's approach was purely mathematical and he refrained from attributing a physical description to any individual entities.

Rovelli admires this approach and builds on it in his recent book *Helgoland*, eventually drawing a stark conclusion: quantum objects, he says, have no independent reality. Instead, they exist only as relationships.

As we stand in the gallery, with Parker's exploded objects looming over us, Rovelli explains it further. "We have discovered that, at the core of the physical reality, it's not particles, it's relational connections," he says. "Each object is defined by the way it interacts with something else. So when it's not interacting, it's just not existing. An object is the ensemble of the ways in which it affects other objects around itself – an object exists reflected in everything else."

It isn't a testable claim, but that doesn't bother Rovelli. "Science is not just about directly testable things," he says. "It's also about finding the right conceptual structure, one that works." In other words, Rovelli believes that, while you may not be able to look at a key and determine whether it will turn a lock, if it is the right key, the door will open. And in his mind, the relational way of thinking can unlock the secrets of the universe, perhaps ultimately uniting quantum theory with gravity. "My main work is to understand quantum gravity: quantum aspects of space and time. And I think this relational way of understanding quantum mechanics is going to work much better."

So where does dark matter come in? It will be possible to shed light on that by applying the relational ideas to black holes, he says. Stephen Hawking showed in the 1970s that a black hole slowly emits radiation, losing mass and eventually disappearing from the universe. The upshot of this is that everything it has ever swallowed must disappear too, including all the information carried in those objects. Since quantum laws don't allow information to disappear from the universe, physicists have named this the black hole information paradox. They have fiery arguments about what exactly is going on and what the paradox tells us about the deep laws that govern physics.

> "I don't think it makes sense to think that there is an ultimate reality"

Relational quantum mechanics could lead us to an answer, Rovelli says. "My hope is that, thinking about quantum mechanics in this relational way, we can get an understanding of what happens to black holes," he says. His suspicion is that remnants of a black hole thought to remain after the process of Hawking evaporation has played out could evolve into something that resembles dark matter. He is far from certain that it will work out, but that's OK too. "A good scientist is never sure," he says.

Century of doubts

If Rovelli is unruffled by the possibility of being wrong, he is also calmly optimistic about the future of physics, despite the many cries that the discipline has hit the rocks. It is true that it has had almost a century of failure in the hunt for dark matter, more than a century of doubts over the meaning of quantum physics and several decades of fruitless searching for a workable quantum gravity theory. But physics isn't "stuck", he says. "We're making enormous progress. We have learned plenty of new experimental facts – for instance that there is no supersymmetry."

Supersymmetry – the hypothesis that an ensemble of particles that mirror the ones we already know about remains to be detected – would have been a problem for some quantum gravity theories, says Rovelli. For him, the fact that supersymmetric particles didn't turn up, as predicted by some, at the Large Hadron Collider was a cause for celebration, not dismay. "It is a good sign from nature saying, 'good, good. You had the right intuition. Go!'"

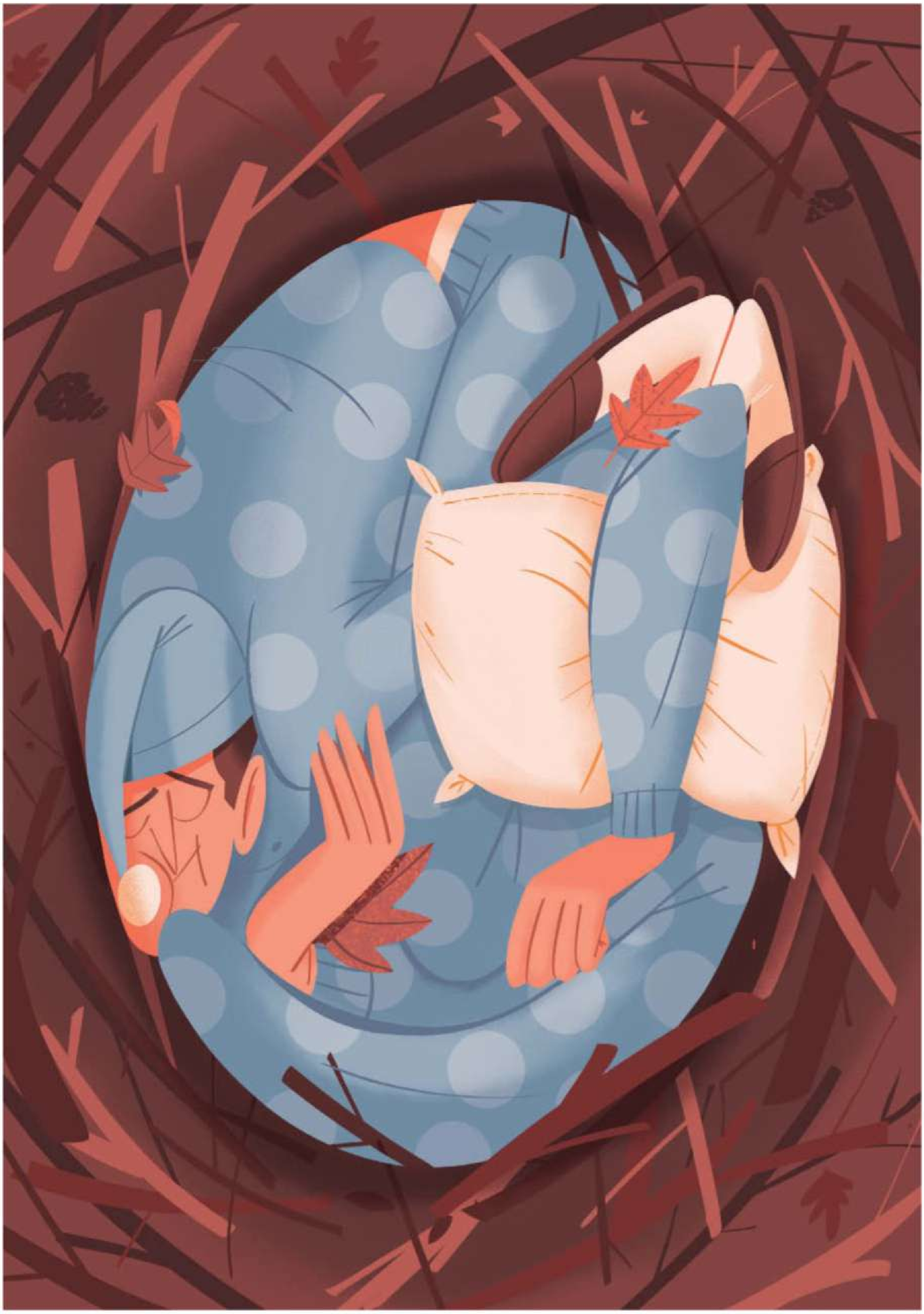
Further through the gallery, we encounter another of Parker's works: a ring of brass instruments suspended in mid-air on fine wires. Each has been flattened by a steamroller. The way they are lit, however, casts familiar-looking shadows on the walls: look only at these and you wouldn't know that the instruments are broken. This room of unsettling, misleading perspectives seems like the right place to discuss the broader view of what we can and can't know about our universe, so I ask Rovelli whether we will live to see a full description of reality's core.

He takes a dim view of the question. "I don't think that it makes sense to think there is an ultimate reality," he says. "A forest seen from a distance is just a velvety green, but then you go closer, and you see the trees: they're real. Then you see the trunk is real, and you see the atoms in the trunks are real. Reality is the ensemble of all these things: they're all real, it's just about understanding things better and better and better. We should get out of this mindset that ultimate reality is matter or language or God or mind or spirit."

Rovelli is similarly dismissive of the search for a "final" theory. "We shouldn't look for the ultimate theory; we should look to solve one problem at a time," he says. "We don't understand the quantum properties of space-time? Let's study this. We don't understand black holes? Let's study this."

It is in each of these searches, he says, that we find fulfilment and each provides further layers of understanding. "Of course we don't understand things well yet: we don't understand how our mind works, for instance. But whether we think of ourselves as social, psychological or chemical beings, these are all interesting perspectives, which are not in contradiction with one another." ▮

Michael Brooks is a consultant for *New Scientist* and author of *The Maths That Made Us* (Scribe)



ANTONIO SORTINO

The big sleep

Were human ancestors able to hibernate and what could that mean for our health, asks **Alex Wilkins**

IF YOU could rewind the evolutionary clock millions of years, you might discover that your ancestors had a remarkable trait. It wouldn't be obvious at first. But in certain conditions – if food were scarce or there were a cold snap – it is possible that their eyes would grow heavy and their bodies begin to slow until, eventually, they switched off entirely. They would be hibernating.

In this low-energy state, today's hibernators can fend off a remarkable array of threats, from the inside and out. Extreme cold and famine are the obvious ones, but hibernation also has the power to combat conditions that plague modern humans, including Alzheimer's disease, stroke and heart attack. It could even hold the key to longevity and colonising space. No wonder some researchers are keen to reinstate what might have been our long-lost superpower.

The idea that ancient humans could hibernate may seem far-fetched, but mounting evidence suggests that many non-hibernating mammals retain an ability to enter reduced-energy states, including through dormant brain-signalling pathways that slow metabolism. "The distribution of hibernating species on the tree of mammals makes the likely conclusion that the common ancestor of all mammals was a hibernator," says Sandy Martin at the University of Colorado. "It's possible we all have the genetic hardware."

It remains to be seen whether any underlying circuitry can be fired up enough to bestow us with some of hibernation's protective properties. But the potential spoils are too great not to try.

Hibernation is often associated with small mammals, such as dormice, hedgehogs and bats, but it is also common among reptiles, amphibians and even insects. It resists easy definition, though. In German, Turkish and many other languages, hibernation translates literally to "winter sleep" – and it does bear a passing resemblance to this. But comparing hibernation to sleep is like comparing apples to oranges, according to Vlad Vyazovskiy at the University of Oxford, who studies both. "There are criteria for defining sleep and they are purely brain-centric, but hibernation is defined based on metabolism," he says. "This means that, technically, you can be awake and hibernating or asleep and hibernating."

In essence, hibernation centres on a state called torpor, in which an animal decreases its physiological activity, marked by a reduction in body temperature and metabolism. The length and extremity of these changes varies hugely. The drop in body temperature can be severe and last for weeks or brief and entail a decrease of only a few degrees. The accompanying metabolic reduction can be near total or only 10 to 20 per cent. What's more, some hibernators regularly come in and out of torpor into states of arousal, while others stay metabolically suppressed.

"Among hibernating mammals, there's a continuum of hibernation," says Matthew Regan at the University of Montreal, Canada. At one end, there is the thirteen-lined ground squirrel (*Ictidomys tridecemlineatus*), one of the most studied hibernators, which lowers its body temperature in successive cycles of torpor and arousal until it is barely above the temperature of its environment. It can stay in this state without food or water for more than six months, suspending many bodily functions and recycling key nutrients through specially adapted processes.

At the other end of the continuum are large species such as bears. The black bear (*Ursus americanus*), for example, lowers its core temperature by no more than about 6°C and reduces its metabolic requirements by a quarter – a significant saving for such a modest temperature decrease. "Bears highlight other means of metabolic suppression that are independent of core temperature. And those mechanisms are really very poorly understood," says Kelly Drew at the University of Alaska in Fairbanks.

Most experts believe that if we are ever to enter a state of synthetic torpor, it will be similar to that of a less-extreme hibernator. "It's not feasible to think that humans could get down to the levels of the small hibernators, but you can get an awful lot of value from the shallow metabolic depression of a bear," says Hannah Carey at the University of Wisconsin. In particular, it could be extremely useful for long-distance space travel (see "To blearily go", page 48).

To begin with, we need to understand the weird processes that happen within the bodies of hibernators. Progress here has been rapid in recent years, not least when it comes to identifying the genes involved. Martin is a pioneer. For decades, she has collected and frozen tissue samples taken from a wide range of mammals over the course of their hibernation. "The idea is that the tissue bank is carefully timed, so that you get good information about levels of gene products, which change across a torpor bout, or change very rapidly during the rewarming period, and change seasonally," she says.

Martin's grand vision was to analyse these timed tissue samples to identify the genes that throw the switches controlling hibernation in mammals. Once located, these genes could be studied and possibly modified to mimic the beneficial properties that hibernation bestows. When Martin started her tissue bank, a dearth of technology and resources made this extremely challenging. It was difficult to look at more than one gene at a time or find which genes were being expressed across the whole organism. But now things are different. "The tools are finally catching up to the ability to actually use [the samples] in a way that will be productive," she says. Progress has been particularly strong in an area of research called comparative genomics, which compares the complete genomes of different species to identify important genes.

Martin retired from active research this year, but she has passed on her treasure trove to one of her ex-students, Katherine Grabek, who co-founded a California-based comparative genomics start-up called Fauna Bio. Grabek and her team are using findings from the tissue bank, along with a raft of other information, such as transcriptomes – descriptions of the different ways genes make proteins – and human gene data, to identify targets for drugs that can replicate hibernation's benefits.

Genomic insights

For instance, the thirteen-lined ground squirrel recycles its urea to preserve nutrients, cleans out harmful brain plaques commonly associated with Alzheimer's in humans, mitigates the insulin sensitivity that comes with huge weight gain before winter and appears to experience no ill consequences from severe spikes and troughs in blood pressure as it comes out of hibernation. By comparing its genome with those from more than 50 other hibernating and non-hibernating mammals, Grabek and her team have already identified molecules that appear to protect against high blood pressure, coronary heart disease and heart infections. As they expand their sample collections and analysis, they hope to identify molecules associated with other conditions that affect human health, and eventually use these findings to design therapeutic drugs.

Other potential payoffs for medicine are coming from research that aims to understand the changes happening within the brains of hibernators. Much of the focus has been on a neurotransmitter called adenosine, which, among other things, is linked with sleep: when adenosine binds to receptors in the brain's hippocampus, neural activity slows and you feel sleepy. In 2011, when Drew and her

The Arctic ground squirrel can lower its body temperature to -2.9°C during torpor

INGO ARNDT/NATUREPL

To blearily go

As the study of hibernation progresses, it has come to the attention of space agencies looking to protect astronauts on long missions. "We have a real interest in understanding this better because it will solve some of our issues, in a very elegant way that otherwise would require developing new propulsion systems to shorten trip durations," says Leopold Summerer at the European Space Agency (ESA), who leads a team that looks at innovative space travel solutions, like hibernation.

If ESA, NASA or SpaceX is to put people on Mars, then astronauts will have to spend months on a tiny spaceship with minimal food, in microgravity where their bones and muscles will waste away, being bombarded by cosmic radiation in the absence of Earth's magnetic field. Helpfully, these resemble many of the conditions hibernators appear able to survive: bears and squirrels can preserve bone structure while in torpor, the state accompanying hibernation in which metabolic rate is reduced. Squirrels have also shown resistance to high levels of radiation while hibernating. And Summerer's team is now testing how the cells of hibernators perform in microgravity to see whether torpor might be a viable spaceflight strategy.

NASA is also funding research in this area and consulting hibernation scientists. One company it is collaborating with is SpaceWorks. Its chief executive, John Bradford, says the firm's aim is to lower body temperature from 37.5°C to around 32°C, which would cut metabolic activity by about 50 per cent. A flight to Mars would take four to six months, he says. "We don't think you could put people in this state for the entire duration. We were envisioning the crew would cycle through these two-week stints of kind of extended sleep periods, and they'd be active for a couple of days, and then go back into stasis again."

Black bears suppress their metabolism without a big drop in temperature

STAN TEKIELA AUTHOR/GETTY IMAGES

colleagues gave Arctic ground squirrels (*Urocitellus parryii*) drugs that either activate or suppress these adenosine pathways, the squirrels spontaneously entered and exited states of torpor. But there was a catch: this only worked in winter, when the squirrels were already primed for hibernating. Why that might be remains a mystery. Still, it left Drew and her team wondering what effect adenosine might have in mammals that don't hibernate.

To find out, they have since done similar experiments with rats. These didn't result in the full metabolic effects seen in squirrels, but the team discovered that boosting the uptake of adenosine in the rats' brains lowered their core body temperatures. Furthermore, with the adenosine drug, there were none of the adverse effects usually associated with hypothermia, such as shivering and metabolic stress. "That's really exciting, because the adenosine mechanism is remarkably effective," says Drew. Her enthusiasm is linked to the fact that, in humans, induced hypothermia is used to treat cardiac arrest – and has the potential to treat strokes too – but the drugs currently given to suppress shivering don't work at very low temperatures.

Another researcher focusing on adenosine is Domenico Tupone at Oregon Health and Science University. He believes it is the key to the metabolic anomaly at hibernation's heart, which he calls "thermoregulatory inversion". In mammals, the normal physiological response to plunging temperatures is for the body to turn to brown fat, which is packed with mitochondria that make energy and generate heat. But during hibernation, the opposite happens: cooling inhibits heat production and warming boosts it. Tupone and his team found that they could induce thermoregulatory inversion in rats by giving them drugs that activate adenosine pathways. "Rats are similar to humans in terms of the internal circuitry of the brain," says Tupone. "What we suspect is that this circuit is also present in humans, but we have lost the ability to trigger it."

Other researchers have homed in on a small part of the brainstem called the raphe pallidus, which helps control automatic bodily processes. Matteo Cerri at the University of Bologna, Italy, and his colleagues found that inhibiting the neural activity of this region in rats and pigs can lead to a state of hypothermia that resembles torpor in hibernators. The researchers have also shown that the raphe pallidus receives signals from the hypothalamus, another key brain region for controlling hibernation. "All this computation about our metabolic and energetic state comes down from the hypothalamus, which is a higher region of the brain, and goes into an older region of the brain, the brainstem," says Cerri. "There, it hits this raphe pallidus region, which will then organise the body's response."

> **"It is becoming clear that we needn't be hibernators to reap the rewards"**

Cerri, Tupone and Drew hope that, as we learn more about the neuroscience of hibernation, we can go beyond turning down heat production to controlling metabolism in other ways. The ultimate prize would be a novel approach to boosting longevity. Decades of research on caloric restriction and fasting have revealed a strong link between metabolism and lifespan. In particular, we know that when nutrients are scarce, a network of metabolic pathways switches from stimulating cell growth to suppressing it, boosting repair and feeding off cellular detritus that would normally cause the cellular damage that results in ageing. Hibernators live longer than non-hibernators of the same size, and new research in both bats and marmots shows that, during hibernation, their bodies age more slowly. This suggests that a better understanding of torpor could provide new insights for anti-ageing researchers.

In the future, drugs might be created that could influence the neural activity involved in hibernation. It might even be possible to do this using the environmental factors that natural hibernators rely on, like the time of year or fasting, says Cerri. There is a long way to go to fully map out and target the brain circuits involved, but it is already becoming clear that we needn't be hibernators to reap the rewards. "These processes may have evolved to optimise metabolic plasticity for an animal's health during periods of torpor," says Regan. "But those processes don't necessarily need torpor to be elicited, or to have some benefit."

While hibernation's mysteries still abound, our efforts to better understand it are finally beginning to gather momentum – and we are now waking up to the potential benefits. "People have been studying hibernation for at least a century," says Carey. "But new technologies are making things a lot easier to get at scientifically. This field is too important to not try to get as far as we can." ▮

Alex Wilkins is a news reporter at *New Scientist*

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Science of gardening

A purple patch for GM food

The first home-grown genetically modified food may be on the horizon, in the form of purple tomatoes, finds **Clare Wilson**

Clare Wilson is a reporter at *New Scientist* and writes about everything life-science related. Her favourite place is her allotment @ClareWilsonMed

What you need

Purple tomato seeds, if and when you can get them

All the usual equipment for growing tomatoes

THE end of the tomato season is approaching in the UK, and I am weighing up the performance of the different varieties I grew and deciding which seeds to buy again. Next spring, US gardeners may have a new option to consider: the first genetically modified seeds for home growers could go on sale there, in the form of bright purple tomatoes.

GM food can be controversial, but the scientific consensus is now that plants with modified genes are no more liable to be unhealthy for us than unmodified ones. Foods containing GM ingredients, such as soybeans and maize, have been eaten in the US since the 1990s with no ill effects, but are banned from sale in many other countries. Even in the US, GM seeds are only sold to farmers.

That may change next year, since a GM tomato aimed at home growers has passed a key regulatory hurdle at the US Department of Agriculture. The tomatoes, from UK-based Norfolk Plant Sciences, have been modified to contain high levels of anthocyanins, antioxidant pigments found in other red or purple fruits and vegetables.

Naturally purple tomatoes are already available, but these only have high anthocyanin content in their skin. The GM tomatoes also have high levels in their flesh, leading to 10 times the amount of the compounds per fruit.

SHUTTERSTOCK/NATTAPOL_SRITONGCOM

Anthocyanins have been shown in animal studies to protect cells from free radicals, highly reactive compounds that are formed when energy is released from glucose. Anthocyanins are said to reduce cancer and heart disease and to be part of the reason why people who eat more fruits and vegetables live longer. This hasn't been shown in randomised trials in humans – although that is also the case for most dietary health claims.

The GM tomatoes won't be sold with any specific health claims, just the vaguer statement that they are "nutritionally enhanced". But these fruits have a benefit that is easier to demonstrate and that I think is more interesting.

The high anthocyanin levels seem to protect them from grey mould, a fungal infection that is often a problem for tomato plants in greenhouses and one that also affects tomatoes after harvest. After picking, the modified tomatoes have double the shelf life of unmodified ones, research by the developers has shown.

Cathie Martin at the John Innes Centre in Norwich, UK, who co-founded Norfolk Plant Sciences and led the team that developed the tomatoes, says the seeds should be popular as home growers like trying out new plant varieties.

That is true for me. I am now coping with a glut of tomatoes, and they sometimes go mouldy. If it becomes possible to buy seeds for high-anthocyanin tomatoes in the UK, I will be keen to put them to a taste test. I bet they would look fabulous in a salad. ■

Science of gardening appears every four weeks

Next week

Citizen science

These articles are posted each week at **newscientist.com/maker**

M.K. ČIURLIONIS
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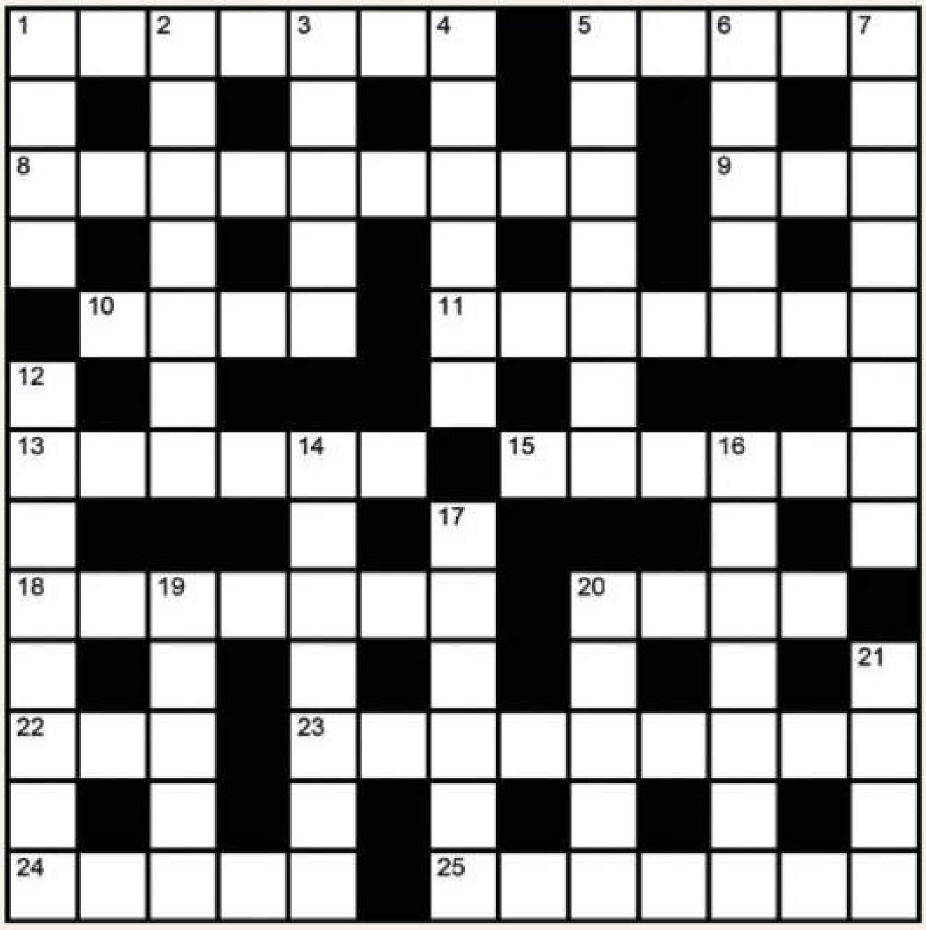

Scribble zone

Answers and the next quick crossword next week

ACROSS

1 Astronomer's reference reconstructed past, including part of galaxy (4,3)
5 Cold, noisy place for storing data (5)
8 Metalloid plant outside entrance to mine (9)
9 Curving shape of parade between ends (3)
10 What's the reason to consume English cheesemaking by-product? (4)
11 Fast mover working on yacht (7)
13 Reveal last bit of tofu and chopped prawn (6)
15 Ness, for instance, wears extremely cute bell-shaped hat (6)
18 I weary myself getting back retired professors (7)
20 Cry about northern elitist (4)
22 Toss out boron and indium (3)
23 Hear a pollster cover a seat, maybe (9)
24 Remorseful feeling with one litre blocking digestive tract (5)
25 Swap two pieces in that woman's gigantic crop (7)

DOWN

1 Starts to sing, ignoring grumpy headmaster's exasperated expression (4)
2 Who juggled after late-starting festival's overhead spectacle? (7)
3 Substantial, like certain whiskies getting a different cap (5)
4 Dryer buildup included in test for acid or base (6)
5 Hilarious calico dashed around back of room (7)
6 Love to diversify source of eggs (5)
7 Discourage holding tin for an American wine server (8)
12 Bus purge destroyed drug-resistant strain (8)
14 New quota includes lithium sample (7)
16 Gleeful laugh upset lieutenant amid mundane task (7)
17 Neptune's position and vertical dimension, top to bottom (6)
19 Seven nuisances exhibiting boredom (5)
20 Take flight, bearing left of the sun (5)
21 Romeo breaks fanciable glassmaker's material (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #173

1 The nene (*Branta sandvicensis*) is a bird endemic to which US state?

2 Which alcohol has the chemical formula C_2H_6O?

3 The pollen-bearing part of a plant's stamen is known as what?

4 Which black hole provided the first major evidence that such objects exist?

5 Name the three physicists who argued that quantum mechanics isn't a complete physical theory in a seminal 1935 paper.

Answers on page 55

Puzzle

set by Steve Wain

#189 Going back in time

My 24-hour LED clock has a six-digit display that shows hours, minutes and seconds. I have noticed that this sometimes means I get palindromic times – those that read the same backwards and forwards (starting at 00:00:00 of course).

The other day, I looked at the clock and the time was a palindrome. In less than 10 minutes, it happened again! Within an hour of that, I looked at the clock again. Another palindrome. But I then had to wait for what turned out to be the equal longest possible gap before the next palindrome turned up. A similar long gap had happened earlier in the day.

What time was it when I first looked at the clock?

Solution next week

Water fall

Where is the water that Europe and China are missing from rivers, reservoirs and underground this year? It must be somewhere.

Hillary Shaw
Newport, Shropshire, UK
This water is elsewhere on Earth. A dried-out reservoir is striking, locally, but not in terms of the whole planet.

Just 2.5 per cent of Earth's water is fresh. The rest is in the oceans. About 99 per cent of that fresh water is groundwater or in glaciers and ice caps, such as those over Antarctica.

Even of the remaining 1 per cent of fresh water, less than a quarter is in lakes and rivers – most is permafrost. So, for every 16 tonnes of water on Earth, just 1 kilogram is in lakes and rivers.

And the biggest reserves of river and lake fresh water are outside Europe and China, in the Great Lakes and the Mississippi, Amazon, Nile and Congo rivers, plus the large Siberian rivers (the Ob, Yenisey and Lena).

> "Even if half of Europe's lake and river water were redistributed elsewhere, the rest of the world wouldn't notice any excess"

So even if half of Europe's lake and river water were missing, the rest of the world wouldn't notice the excess, any more than we see a deficit when one country experiences bad floods.

Guy Cox
Sydney, Australia
There does seem to be a certain irony that this question appeared in the same issue (3 September) that reported floods in Pakistan, with huge loss of life and homes. South-east Australia has also had two series of catastrophic floods this year. My home still isn't fully habitable. Yes, the water does go elsewhere.

How can professional gamblers earn a living if the house always wins?

ADAM GAULT/GETTY IMAGES

This week's new questions

Odds-on **If "the house always wins", how do professional gamblers make a living?** ***Grace Benham****, Poole, Dorset, UK*

Crop swap **Christopher Columbus's expeditions to the Americas brought tomatoes, peppers, potatoes, beans, squash and maize to Europe, but what about the other way? What crops grew in Europe that Native Americans didn't have? And what crops were present on both sides at that time?** ***Eric Kvaalen****, Les Essarts-le-Roi, France*

Stephen Johnson
Eugene, Oregon, US
The water missing from rivers, reservoirs and aquifers in Europe and China has been distributed around the world, primarily by the atmosphere.

At any time, the atmosphere contains approximately 12,900 cubic kilometres of water. With changing weather patterns, atmospheric moisture is falling as rain and snow in different places and at different rates than previously.

In 2022, this has given us droughts in China and the west of North America, and flooding in the southern US.

As well as this, many rivers are fed by glaciers and snowpacks that are diminishing or vanishing due to warmer temperatures.

Additionally, aquifers are diminishing because usage rates often exceed the recharge rate. Aquifers can recharge as slowly as 130 centimetres a century, but can be pumped out at rates of metres per year.

Water being pumped out of the ground in California today is often as much as 20,000 years old.

Graham Smith
Melbourne, Australia
The total amount of water in the world is unchanged, it is the distribution of the water that has changed. While China and Europe have been in drought, Pakistan and Australia have had record floods.

Most rain originates as evaporation from the sea, and this evaporation increases strongly with higher air or sea temperatures. The evaporated water is dropped as rain when the air cools below its saturation point (the maximum amount of water it can hold at a given temperature). For example, a cubic kilometre of saturated air – a small cloud – at 20°C (68°F) holds 18,000 tonnes of water. If the temperature drops to 10°C (50°F), then it can only hold 9000 tonnes, so the other 9000 tonnes have to fall as rain.

A 2°C rise in air temperature increases the amount of water in saturated air by about 10 per cent, meaning that it can hold more moisture before it drops its rain. As a first approximation, this might be expected to result in a 10 per cent global increase in rain, which would be considered beneficial in many parts of the world, but climate models also predict changes to wind patterns, which will change rainfall patterns.

It is therefore not surprising that extreme "once in 500 years" floods and heatwaves are occurring somewhere in the world more often.

For more on droughts, see page 16 – Ed

Hitting the spot

What happens to a photon after it hits the retina of my eye?

Herman D'Hondt
Sydney, Australia
Like everything else in life, the photon eventually becomes heat – an increase in entropy.

When the photon strikes one of the light-sensitive cells in the retina, it is absorbed by an opsin molecule. The colour-sensing cone cells use three different photopsins,

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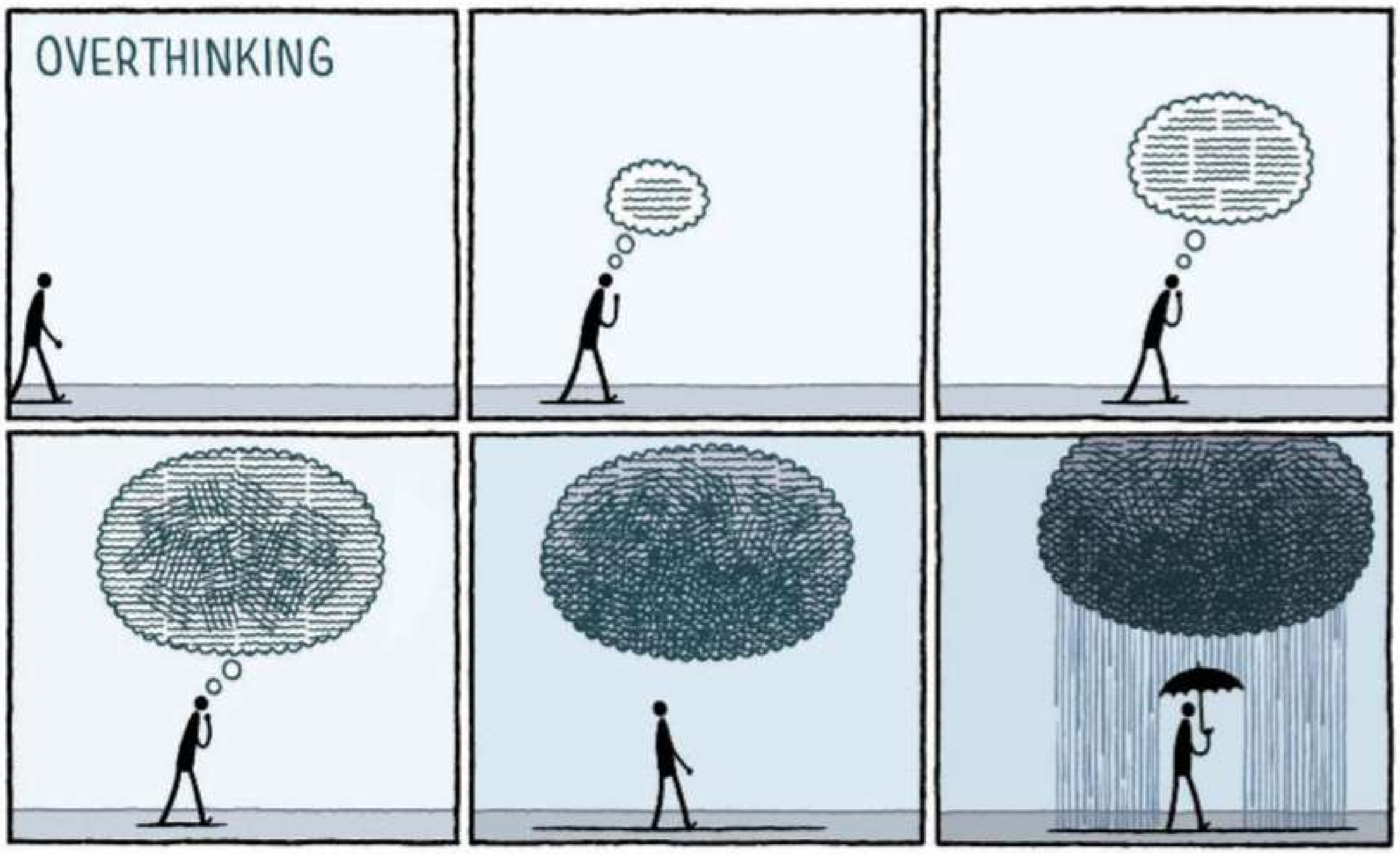


one for each primary colour.

The rod cells use rhodopsin, which senses only light intensity, not colour. In all cases, the opsin absorbs the photon, which vanishes out of existence. However, its absorption by the opsin transfers the photon's energy to that molecule. That triggers an electrical signal that is transmitted to the brain by the optical nerves. The opsin itself returns to its original, non-excited state and dumps the released energy as heat.

Although at that point, the photon no longer exists, its effects can be very long-lasting: when the signal reaches the brain, it may be stored as a long-term memory, or it can trigger some action by the body. The photon itself, however, has disappeared long before any of those things happen.

Mike Follows
Sutton Coldfield,
West Midlands, UK

The photon gets absorbed and ceases to exist. When looking up at the night sky, it is amazing to think that photons may end their journeys in your eye, having been launched billions of years ago from a star that no longer exists.

> **"The photon may no longer exist, but its effects can be long-lasting if it triggers a signal to the brain that is stored as a memory"**

Photons are force particles (as opposed to particles of matter) whose sole purpose is to mediate the electromagnetic force. When the photon enters the eye, it can be absorbed by photoreceptors.

These proteins change shape when activated by photons, which ultimately controls the passage of ions through the photoreceptor cell, so that the light energy is transferred as an electrical signal along the optic nerve to the brain.

Pat French
Rockhurst, Shropshire, UK

Whether it stimulates a sensor cell in your retina or completely misses a suitable receptor, the light energy that is the photon dissipates as a tiny amount of heat. It isn't particularly warm.

A photon reflected from a red rose might have a wavelength of 700 nanometres, giving it an energy equivalent of 1.8 electronvolts, or 2.9×10^{-19} joules. That is around 10 billion billionths of the energy required to lift a large potato 1 metre high, so not a lot!

Hairy issue

Why do humans have pubic hair, when other "hairless" mammals, like pigs and elephants, manage without it? (continued)

Glyn Watkins
Bradford, West Yorkshire, UK

My understanding is that pubic hair evolved to help humans smell more, like the wick in a fragrance lamp. Without pubic hair, pheromones produced by humans would evaporate away with sweat. The fact that pubic hair covers our smelliest bits can't be a coincidence. ▮

Answers

Quick quiz #173
Answers

1 Hawaii – it is also known as the Hawaiian goose
2 Ethanol
3 The anther
4 Cygnus X-1, detected in 1964
5 Albert Einstein, Boris Podolsky and Nathan Rosen

Quick crossword #118 *Answers*

ACROSS 7 Zugzwang, **9** Osmium, **10** MIRV, **11** Kookaburra, **12** Egg sac, **14** Opopanax, **15** Socket, **16** Zenith, **19** Sapphire, **21** Ninety, **23** *Deep Impact*, **24** Bark, **25** Pigeon, **26** Epidemic

DOWN 1 Turing, **2** Azov, **3** Backache, **4** Potato, **5** Amputation, **6** Auerbach, **8** Googol, **13** Sock puppet, **15** Snake oil, **17** Einstein, **18** Hexane, **20** Immune, **22** Turbid, **24** Beep

#188 Four forgetful footballers
Solution

Interlecht were the champions.

The results for each team were three of 3-0, 2-1, 1-2 and 0-3, and the four teams' total goals must have been six, five, four or three in some order. The teams that scored six and five goals both won two games and lost the other; the highest/lowest-scoring teams won/came bottom of the table on goal difference. Cleverton lost 3-0 to Smarta Prague and must have ended bottom. Astutegart weren't bottom, so must have won a game 3-0, and it must have been against Smarta Prague. Interlecht are the only team who didn't lose a game 3-0, so were the top-scoring team – hence champions.

Time to retire

How to spur clear-thinking and sophisticated after-dinner conversation? Here is one approach Feedback is considering.

Step 1: Serve tea and cigarettes. (NOTE: Cigars are permissible, if anyone demurs about puffing cigarettes for "health" reasons.)

Step 2: Dramatically recite a brief passage from a new paper called "Study on the effects of combined tea drinking and mental activity after dinner on smokers in China" by Zhongbo Chen at Ningbo University in China and colleagues. This is the passage to declaim: "The relationship between smokers who consume tea, engage in mental activities after dinner, or both (drinking tea and engaging in cognitive activities after dinner together), and daily cigarette smoking or nicotine addiction must be clarified."

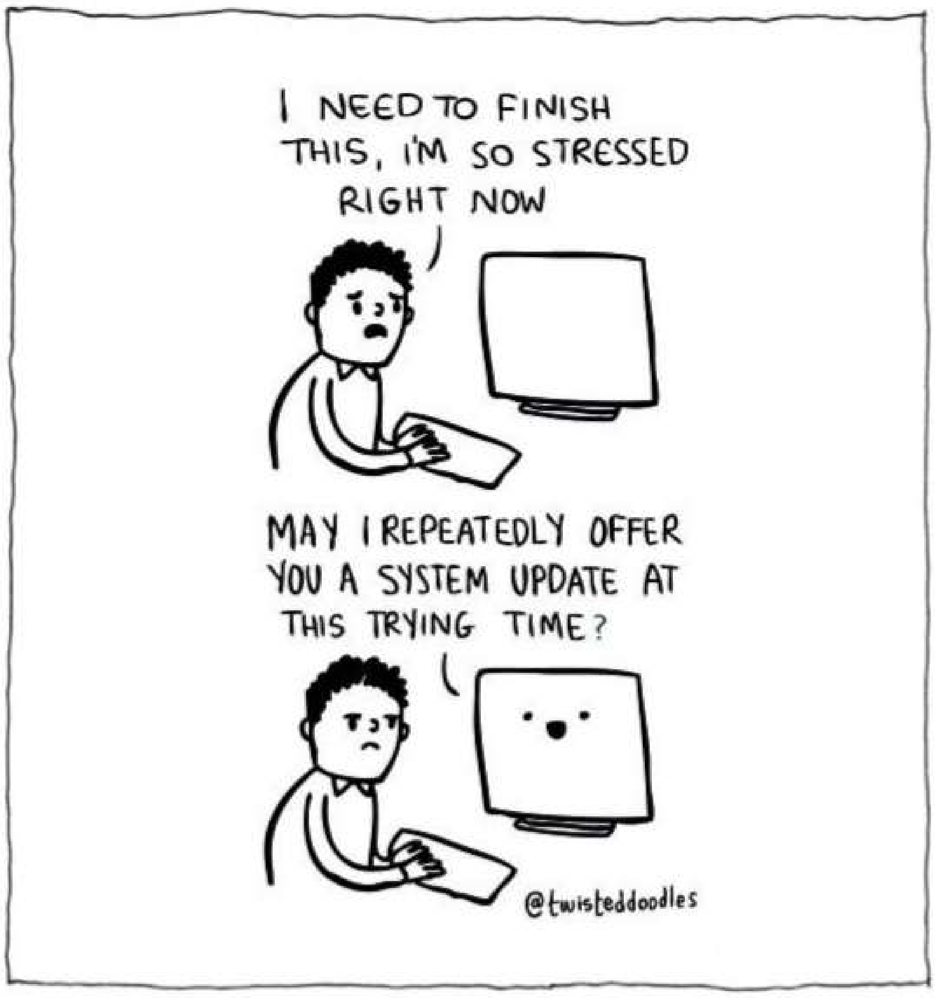
Step 3: Hand each guest a sealed envelope containing a printed copy of that study. Instruct your guests to open the envelope.

Step 4: Then, sit back and watch the conversation inevitably flow downhill to the sea.

Enhanced version: If your salon gathering is large, you can augment the intellectual depths by following a recipe in the study: "Smokers were divided into four groups according to behaviors: 1) no drinking tea and no mental activities after dinner group; 2) only drinking tea; 3) only mental activities after dinner; and 4) combination behaviors (drinking tea and mental activities after dinner together)."

Finally, send your guests into the night all abuzz. Announce that, next time, you will savour a paper published in 1995 in the journal *Nature*. It is called "Making a meal of mother".

Twisteddoodles *for New Scientist*


I NEED TO FINISH THIS, I'M SO STRESSED RIGHT NOW
MAY I REPEATEDLY OFFER YOU A SYSTEM UPDATE AT THIS TRYING TIME?
@twisteddoodles

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Consideration of items sent in the post will be delayed

Will it ever fly?

Mathematical formulae look impressive. But as most scientists know, it is easy to create a new formula (much as it is easy for an author to write a new sentence). What is difficult is to adjust a formula (or a sentence) so it accurately describes what you hope it describes.

It would be easy, for example, to write a formula that specifies how many bugs to substitute in place of butter, if you want to produce entomologically fortified butter. Easy, that is, if you don't much care about the satisfaction of those consumers who will eat the butter made according to your formula.

Reader Sonya Taafe informs Feedback of a study that goes in pursuit of such accuracy. The paper is called "Consumers' perception of bakery products with insect fat as partial butter replacement". Claudia Delicato at Ghent University in Belgium and her colleagues published it in *Food Quality and Preference*.

The research was explicitly meant to "explore the potential of bakery products containing black soldier fly larvae fat (BSF LF) as an ingredient".

Using three varieties of butter (ordinary butter, butter that is 25 per cent BSF LF and butter that is 50 per cent BSF LF), the researchers baked cakes, cookies and waffles. They served the treats to 344 volunteers. Àpres-meal surveys, they say, show that black soldier fly larvae fat can replace 25 per cent of the butter in baked goods and maybe up to 50 per cent in waffles "without influencing" consumers' acceptance.

This dab of maths might ease what another study calls "the need of information campaigns to emphasize positive sensory attributes of edible insects".

Watch your language

Your name, whatever it is, may have depths of meaning undreamed of by your parents – exuberant meaning in one or more of the world's 7000 or so currently spoken languages.

The Ethnologue organisation compiles a list of most of those languages, some of which have names perhaps surprising to anyone who speaks or reads only English. Languages notable in that way include Ache, Anus, As, Bun, Chug, Ding, Dong, Eton, Fang, Fur, Goo, Gun, Hermit, Ha, Ho, Label, Libido, Loo and Sop.

A website called Glottolog also aims to keep track of the languages, estimating whether each is in good shape or threatened, moribund or extinct. Glottolog's tally suggests that Ethnologue's list includes some languages that are kaput. Reckoned Glottologically, we, the people of Earth, currently speak about 6300 languages, all told.

Then, there is the separate matter of secret languages. One can't say too much about that, for obvious reasons. David Prager Branner says 48 pages' worth, though, in an essay in a book published in Chinese by the University of Hong Kong Press in 2010. The essay is called "Motivation and nonsense in Chinese secret languages".

Branner says the existence of a language called Faho is puzzling: "The ordinary local speech of Sibǎo – not Faho – is notorious across the whole of Liánchéng county because everyone claims to find it incomprehensible. Why would people whose neighbors already cannot understand them need an extra layer of secrecy in the form of a secret language?"

Perhaps even more puzzling is an experiment done by W. C. F. Krueger back in 1934. Krueger spelled aloud 2183 nonsense syllables to 586 college students. He asked the students to write down each syllable on paper and to try to immediately suggest a meaning.

Krueger reported, in the *Journal of Experimental Psychology: General*, that DOC, DOL and GAP inspired the greatest number of responses, while XOJ, XIW and XEJ generated the fewest. That is Krueger's entire report. ▮

Marc Abrahams

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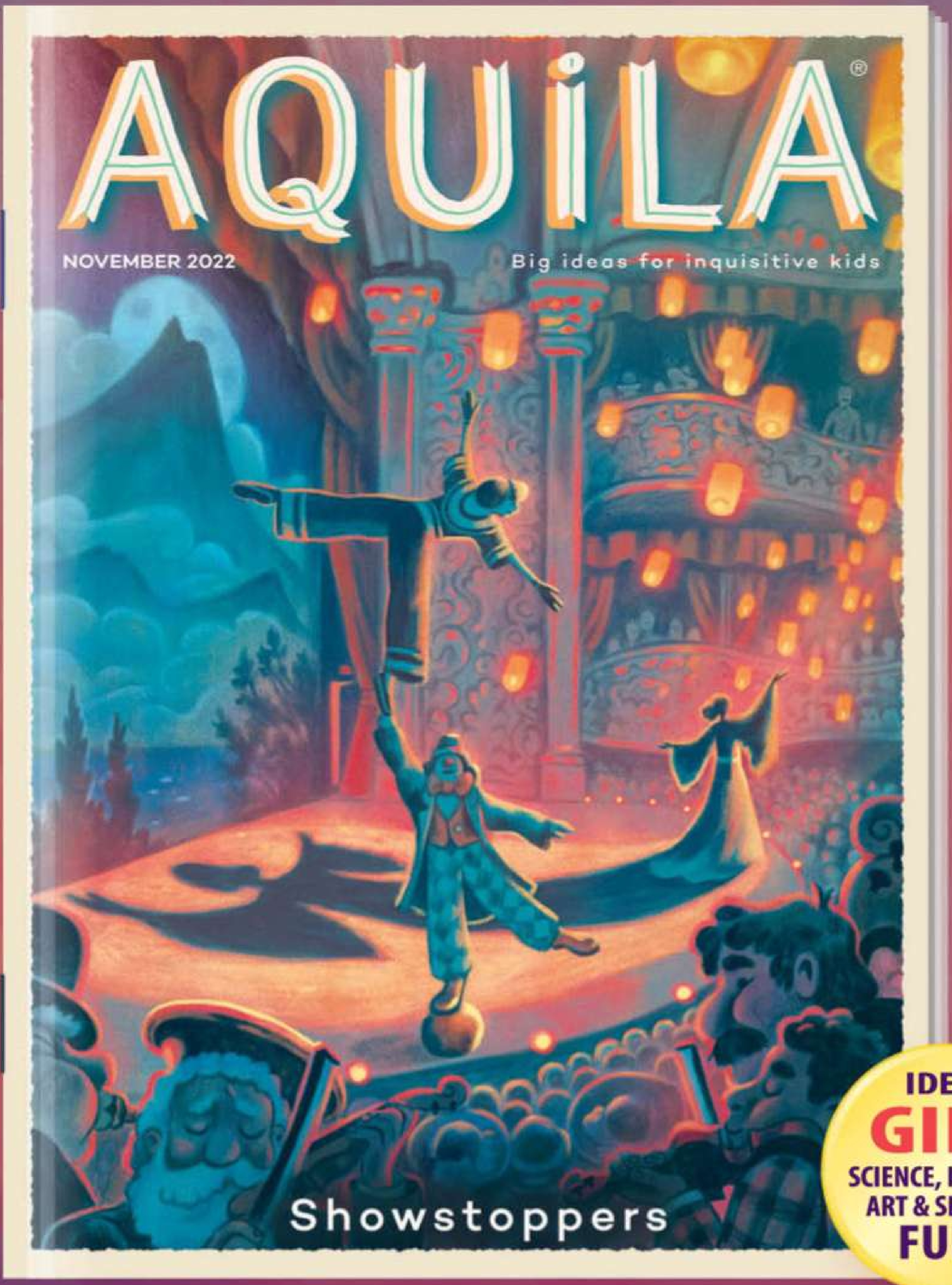

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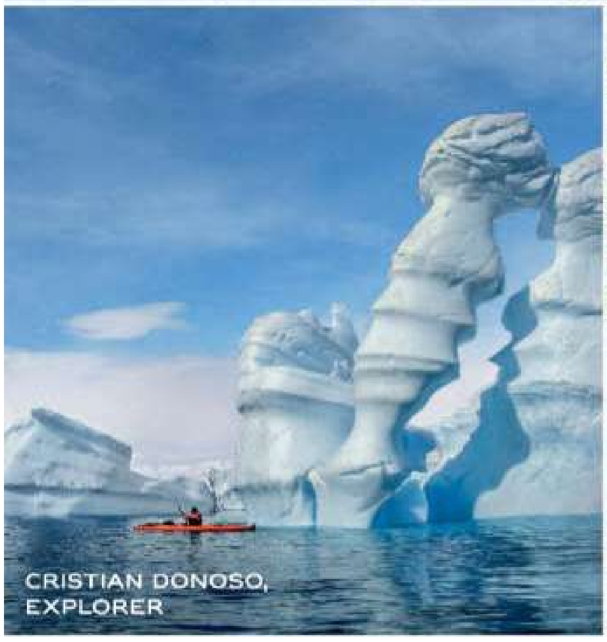
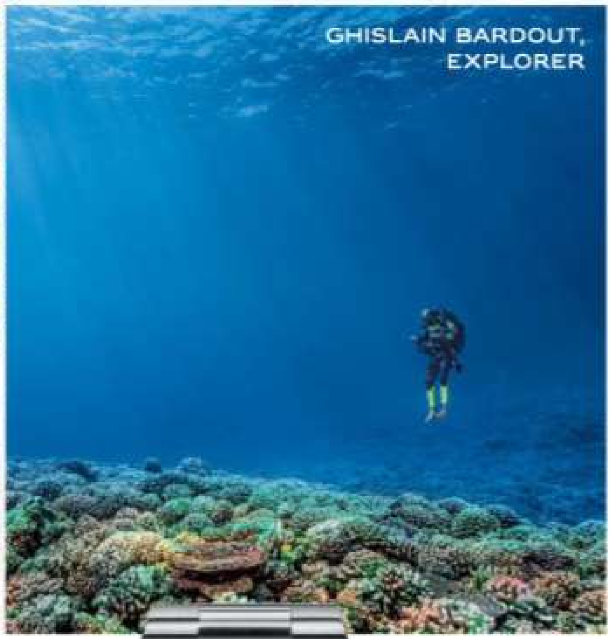


CRISTIAN DONOSO, EXPLORER

TOPHER WHITE, CONSERVATION TECHNOLOGIST

FRANCESCO SAURO, EXPLORER



GHISLAIN BARDOUT, EXPLORER

WHAT DO THEY SEEK?

Explorers, adventurers, scientists. Men and women who always broadened the horizons, for all humankind to share. Rolex was at their side when they reached the deepest point in the oceans, the highest summits of the Earth, the deepest jungles and both poles. But now that we know, more than ever, that our world has its limits, why do they continue to venture out there, again and again? Certainly not for kudos, accolades, or an ephemeral record. What they truly seek is to understand more intimately how complex and delicate our planet is, to document its change and how together, we can affect it for the better. So as long as they need it, we will be at their side. Because today, the real discovery is not so much about finding new lands. It's about looking with new eyes at the marvels of our planet, rekindling our sense of wonder, and acting to preserve our pale blue dot in the universe… **Doing our very best for a Perpetual Planet.**

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